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Learning by experimentation: Children's laboratory experiences at the polytechnic institute of tomar

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Abstract

Background: The Polytechnic Institute of Tomar (IPT), located in Central Portugal, created the Academy of Science, Art and Heritage (ACAP) in 2013 for children aged eight to fourteen. Running during holiday periods, the ACAP was created with the purpose of educating by stimulating creativity and learning through observation, experimentation and construction in a scientific, diversified and happy learning environment.

Purpose: This paper describes the work and challenges faced by IPT Laboratories of Archaeology, Conservation and Restoration, Chemistry, Engineering, Graphic Arts, Physics, Photography and Tourism in the organisation and conduction of mini practical workshops for groups of up to twelve children.

Methods: With the maximum duration of one and a half hours, the workshops are conducted by a teacher or lab technician with the assistance of IPT student monitors and are organized so as to provide a learning space to perform, test and creatively apply recently acquired knowledge. For a symbolic enrolment tuition, the children stay within IPT premises for a full day and are offered lunch and two snacks.

Results: Children's increasing interest in work in a laboratory environment, gradual development of their skills, reasoning and motor dexterity capabilities, the learning experience as part of a team, the increasing interest and happiness of parents, and the positive contribution of IPT in helping student monitors financially, as well as the dissemination of IPT work and expertise among the local population.

Conclusions: The positive and increasingly high development of the children and the beneficial interaction between the university environment and its local population.

Keywords: Learning, Creativity, Experimentation, Leadership, Entrepreneurship, Interdisciplinarity

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1. Introduction

The Polytechnic Institute of Tomar (IPT), located in Central Portugal, is comprised of three schools: the School of Technology (ESTT) and the School of Business (ESGT) in Tomar and the School of Technology (ESTA) in Abrantes. It has a comprehensive educational offering in areas ranging from science, technology, arts and humanities and about 63 academic programmes (levels 5, 6 and 7).

It is widely acknowledged that education is the cornerstone of society because it can generate wealth and effectively deal with the socio-economic changes resulting from human evolution. It is therefore crucial that children have the opportunity to learn in a playful manner, based on experimentation, in order to promote interest in the scientific, technological and artistic fields at an early stage of their education.

Children have a natural curiosity, a willingness to observe, manipulate and complete tasks through experimentation. They often question the way information is communicated because it does not answer their questions. Sometimes teachers are concerned about complying with ministerial programs to meet the requirements of national exams. They pour out the information and overwhelm students with lots of homework that turns out to be more of a repetition of what was done in the classroom. Therefore, today's schools do not meet the individual needs of the children. Course curricula and learning goals are the responsibility of the Ministry of Education and Science. Together with current curricula, the goals are the basic references for educational development: they establish the priorities within course contents, defining the knowledge to be acquired and the skills to be developed by children at different levels of education (Diário da República, 2012).

Concern for children's development and particularly about their learning is enormous. There are numerous publications and opinion articles on this issue that speak about the importance of such actions. Johnston refers the importance of quality scientific practices with children interacting with well trained and qualified adults (Johnston, 2005). The psychologist and Professor Eduardo Sá in his latest book "Today I am not going to school: why is it that good students do not always have good grades?" refers with apprehension to the current state of education in our country and the impact it is having on our children (Sá, 2014). In Portugal there are some initiatives to promote Science (and only focused on this thematic) within the framework of the Science Alive program (www.cienciaviva.pt), but similar activities in the region of Tomar are still scarce.

Given this scenario, the idea arises: if one cannot "create" an ideal school, at least some extra learning activities can be provided that meet the best interests of the children.

Within the scope of its mission, IPT values, stimulates and promotes activities relevant to society, including the dissemination and transfer of knowledge, promoting and organising actions to support the diffusion of the humanistic, artistic, scientific and technological culture, and providing the necessary resources.

As a local education provider, the governing Board of IPT decided to approve the creation, in 2013, of an educational project and support unit named Academy of Science, Art and Heritage (ACAP), where all these areas are brought together in a single project. Focusing on the establishment of a constructivist approach to child and youth knowledge, it is targeted towards children aged between eight and fourteen, with the aim of educating and stimulating creativity and learning through observation, experimentation and construction providing a scientific, diversified and happy learning environment for children.

This paper presents the work and challenges IPT laboratories and departments, teachers, students and staff were faced with, while organising and running mini practical workshops for two groups of up to twelve children.

2. The Academy of Science, Art and Heritage for children

Albert Einstein said that "The mind that opened up to a new idea never returns to its original size". His metaphor referred not to a physical growth of the brain, but to its intellectual development due to environmental stimulation.

The project created within the ACAP aims to produce a set of actions which, it is hoped, will spread interest in science and technology, culture, arts and heritage among a younger population, from eight to fourteen years old, addressing priority training topics available from the IPT's scientific community. It is a broad effort intended to promote scientific and artistic culture as a tool to stimulate the learning process.

The basis of the constructivist theory is that "the individual is seen as creator of his own knowledge, to process the information obtained by experience" (Spodek & Saracho, 1998). In this sense, ACAP intends to offer the local youngsters a set of activities to build knowledge in an experimental perspective that includes the manipulation of concrete materials and performing tasks in which children (or young people) may be motivated to question, observe, reflect, build and conclude, that will help them in their future work and, perhaps, research (DeJarnette, 2012). It also intends to raise children's awareness of the value of cultural heritage, encouraging them to become active participants in its protection and preservation.

For the development of this project, interactions were established with the local population in order to involve them in the IPT scientific community.

2.1. Purposes

During school holidays (Christmas, Easter and summer) parents need help and to feel reassured that their children are properly cared for. In Tomar, the provision of playgroups is, for the most part, limited to routine manual work and already known sports activities. Therefore, the several workshops developed by the ACAP, related to science, technology, art and heritage, held in the various IPT laboratories were thought to help parents in their parenting tasks. In addition to being an excellent supplement to children's' development, parents know that the activities provided by ACAP are broadening horizons for their children. Science, artistic stimulation, and awareness-raising for cultural heritage have in common the fact that they are ways of acquiring knowledge and turning it into something else, often in an innovative way. The policy of the ACAP is based on a learning process that can harmonise these three fundamental aspects, and contribute to sustainable cognitive development of its participants.

In this context, its priority goals are:

- Attract the interest of a younger population to science, technology, culture, art and heritage.
- Educate and stimulate creativity through observation, experimentation and construction.
- Offer workshops with different dynamics and make use of a wide range of materials, not normally available in their classroom environment.
- Provide skills for the development of sustainable activities, including recycling, renewable energy and heritage preservation.
- Promote entrepreneurship through the development of competencies and skills fostering creativity and research.

In addition to hosting children during school holidays, the ACAP also visits elementary schools (1st and 2nd cycles) where it promotes learning through experimental activities related to the subjects listed in their respective syllabus. It also visits after-school centres for children (ATL) run by local schools. Throughout the school year it also supports specific weekend actions or theme weeks in collaboration with external entities such as the Convent of Christ, Town Councils and Libraries, amongst others.

2.2. Team members

In order to meet such a broad spectrum of activities, it was necessary to gather a vast project team which was led by the Head of the ACAP. In that sense both IPT personnel and external collaborators were contacted and challenged to participate in it.

IPT members of the ACAP are, in general, professors and assistant laboratory technicians from different Departments and Laboratories (a specialized team in constant renewal and knowledge updating comprised of researchers in several areas of knowledge such as art, biology, chemistry, conservation and restoration, engineering, environment, photography, mathematics, physics, and tourism). There are also employees (computing, image and communications office, secretariat, cleaning staff, and social services SAS), and monitors (trainees and volunteers). Some of these students are financially helped by IPT as student collaborators. All collaborators have a broad technical, scientific and educational training, which enable them to participate in the preparation and implementation of scientific, cultural and artistic activities.

External collaborators for these workshops are the Tomar City Hall, the Sport Club of Cem Soldos, the companies Sketchpixel plus Esri-Portugal-Systems & Geographic Information SA, Miss Andreia Maia, the Gualdim Pais Philharmonic Society and the Tuna Templária (a group of university students who play traditional instruments and sing serenades wearing traditional university outfits).

2.3. Planned activities

The workshop activities for children are proposed by each department or laboratory involved in the ACAP project, as generally shown in the organigram in Figure 1. All the activities are coordinated and supervised by the Head of the ACAP.

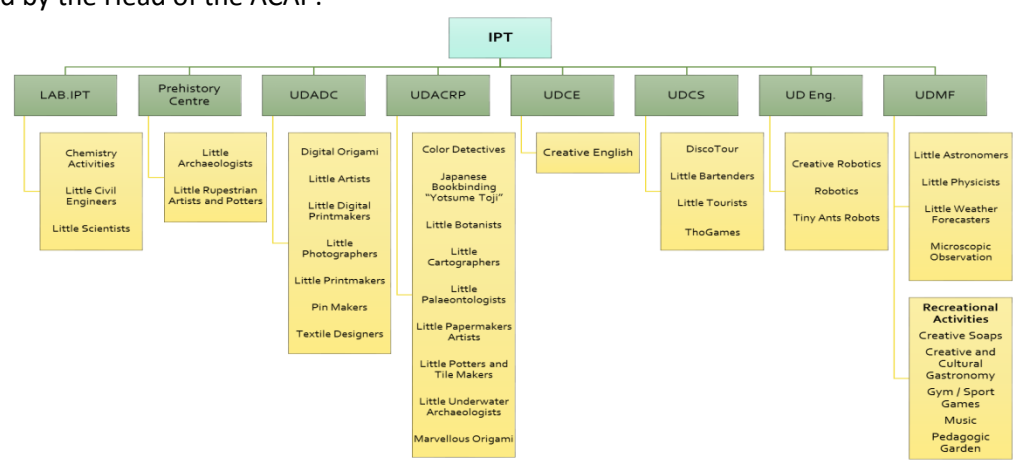

Figure 1. IPT Departments' organigram and respective list of activities for the six Academy editions.

The participating Departments are the LAB.IPT, Prehistory Centre, UDADC (Arts, Design and Communication), UDACRP (Arts, Conservation and Restoration, and Heritage), UDCE (Business), UDCS (Social Sciences), UD Eng. (Engineering), and UDMF (Mathematics and Physics).

More than 40 activities were proposed, prepared and applied to the ACAP. Activities were supervised by IPT professors and technicians, accompanied by monitors who were mostly students of various IPT courses, who guided the children around the various laboratories, took them for meals and also collaborated in the activities. The result was days of scientific, cultural and recreational activities taking place in fully equipped laboratories and with the supervision of qualified interdisciplinary teams.

In addition to the scientific, technical and artistic activities taking place in laboratories, there were also recreational and sports activities such as crafts, music, magic, traditional games, capoeira, and judo, amongst others. One of the recreational activities that deserves special mention is the pedagogic garden, which promotes sustainable development and creative and cultural gastronomy for cooking various dishes in the IPT cafeteria using, whenever possible, the organic products planted by the children themselves (from their own garden).

Most activities are conceived by those in charge of them but there are a variety of science books of which we highlight the recommendations by the physics professor Carlos Fiolhais which can be used as a base for developing workshops. Good examples are: Gigli, 1983; West & Parker, 1994; Gardom & Milner, 1993; Couper & Henbest, 1993; Drew, 1993; Wilkes, 1994; VanCleave, 1993; Centro de Ciência de Ontário, 1994; Jobb, 1993; Elkington & Hailes, 1992, to name just a few.

2.4. Organisation of the ACAP

Once the project was launched, it was necessary to create a Web page and a Facebook page for its dissemination. The IPT's Communications Office developed creative photographs for a banner, for the web page background, as well as for a logo. The next step was performed by the Computer Unit in creating the web page. These pages also contain information and activity details, as well as photos and video reports.

Logistics was the next step. There was the need to provide for a proper base classroom for the children, in which they could play and be creative merely for the fun of it. A two-room classroom, specially decorated and refurbished was provided for that purpose only.

There was the need to hire monitors to supervise the children and it was decided IPT students should be provided with the opportunity to collaborate and earn some money. Engaging faculty members, technicians, staff and students in the workshops and organising schedules and logistics was challenging but feasible.

ACAP ID cards and a uniform with a cap were created for the participants.

At the beginning of each academic year, ACAP activities and its financial plan require approval from the Board of IPT. This plan, drawn up by the Head of the ACAP, includes the planned activities, the necessary materials to perform the activities, the children's insurance and lunch, the monitors' fee, and IPT logistics. After approval, it is also necessary to coordinate the whole work with the staff, faculty members and collaborators.

During the activities the Head of the ACAP is present to supervise and ensure that all goes according to plan.

This was all a great team effort to promote a scientific and artistic culture as a tool to stimulate the learning process.

3. Methodology

The ACAP's project is to take place predominantly during the children's holiday seasons of Christmas, Easter and Summer. Before receiving children, the faculty members and laboratory technicians, and monitors, supervised by the Head of the ACAP, plan and organise the activities, and prepare the laboratory spaces and materials to be used, in order to provide the children with a safe space to learn, test and creatively apply the recently acquired knowledge. A summary of workshop titles and their description is provided in Table 1.

The dissemination of the activities is made through the Web at http://www.academiacap.ipt.pt/inicio/ and www.facebook.com/academiacap. Online pre-registrations are accepted by order of registration until the existing vacancies are filled.

There was naturally a need to provide funds for some of the workshops and for children's meals. For a symbolic enrolment tuition, the children could stay within IPT premises for a full day, and were provided with lunch and two snacks, in addition to the scheduled activities.

The ACAP is keen to ensure a quality teaching/learning experience and at the same time provide a safe environment. The groups of children need to be adapted to the spaces available and the type of activity provided. For this reason participants were divided into two shifts, interchanging laboratories and activities.

With an average duration of one and a half hours, fun activities such as games and some crafts can also depict the respective holiday season. Participation certificates are delivered on the last day of activities.

Table 1. List of workshop activities and their description.

Activity Name	Activity Description
Chemistry Activities | Little Scientists	Magic blow, artificial rain, coloured foam, "Devils Blood", lava lamp, perfume, scented candles, rubber balls, industrial paper, colour flowers, soap bubbles, cartoons, invisible ink, egg white foam, Coca-Cola blast, volcano, rainbow, acid rain… (Wilkes, 1994; VanCleave, 1993).
Colour Detectives	How colour can be created and perceived, knowing colour theory through fun exercises.
Creative English	English playground | Play "All great achievements require time: a day in an Indian boy's life".
Creative Robotics | Robotics | Tiny Ants Robots	Build robots and explore their capacities | Contact with LEGO software MINDSTORMS NXT (Valk, 2014), so to build a t-shirt folding robot with LEGO parts | Play with little track following robots on a test track. (Yuen, T. et al, 2014).
Creative Soaps	Create soaps with different scents and colours.
Digital Origami	Construct digital origami animals with the graphic program Illustrator.
DiscoTour	Decorate the room with newspaper clippings and photographs depicting the UNESCO heritage.
Gastronomy	Creative jelly gums, cultural and vegan gastronomy.
Gym | Sport Games	Capoeira, Judo and Kempo first steps | Football, basketball, volleyball, tennis, traditional games.
Hispano-Moorish Art Workshop	Build a mosaic panel as it was made in the 12th to 14th centuries, during the Islamic occupation of the Iberian Peninsula.
Japanese Bookbinding "Yotsume Toji"	Manufacture small books with decorative recycled papers and cardboards, sewn in the Japanese way (Ikegami, 1986).
Little Archaeologists	Dig and search for ancient civilizations and learn about our past | Look for dinosaurs.
Little Artists | | Little Printmakers Pin Makers | Textile Designers	Make ancient marbled paper | Make a small 17th century book | Decorate wooden boxes | Print pins | Textile design, serigraphy and how to print T-shirts and linen bags.
Little Astronomers	Night watching of the moon, planets and stars (Couper & Henbest, 1993).

Little Bartenders	Cocktails history (Carlin, 2012) and how to create them (Brandt, 1999).
Little Botanists | Microscopic ob.	Botanical and microscopic observation | Microscopic observation of garden microorganisms.
Little Cartographers	How to locate sites, places, streets and points of interest on both paper & digital maps.
Little Civil Engineers	Learn about impulsion, recognise different liquid densities and how a weight acts on them | Make a concrete Fame Walk | Create mortar paperweights, and determine mortar resistance | Make a house skeleton | Why a tilted building stands up (Suescun-Florez, et al., 2013).
Little Digital Printmakers	Visit the typography, create digital postcards and print them.
Little Paleontologists	Learn how fossils are formed and make a cast of a bone.
Little Papermakers Artists	Create handmade paper from recycled papers, decorated with glitter and cooking herbs (Grummer, 2011; Reimer-Epp & Reimer, 2002).
Little Photographers	Photogenic drawings on paper and cloth | Make drawings with light | Construction of a manual camera (Gigli, 1983).
Little Physicists	Hands-on micro electricity for measuring biological cells | Observe temperature increase in electrical wires | Build electromagnets | Design Christmas lights | Convert chemical energy into electricity, light, thermal and mechanical energy | Physics Web Games | Challenges of everyday life with the units of measurement (Drew, 1993).
Little Potters	Cast modeling and clay decoration ("*esgrafitado"*, incision, stamping)
Little Rupestrian Artists and Potters	Learn about the past through cave paintings and how to work ceramic clay pottery.
Little Tile Makers	Painting and glazing of a traditional tile.
Little Tourists	Field visits: Convent of Christ in Tomar and Matches Museum | Treasure Hunt | Wind Mills | Recycle Tour | CineKids. | Artistic Footprints.
Little Underwater Archaeologists	Learn how to breathe through a diving suit and about our underwater archaeological heritage.
Little Weather Forecasters	Create homemade weather measuring instruments | Learn about the fantastic water cycle.
Marvellous Origami	Basic Origami: Suiren waterlily, Tsuru bookmarker, Masu box.
Music	Experiment with different musical instruments with the help of teachers and local music schools.
Pedagogic Garden	First rules, plant and care for an aromatic garden, and harvest products from it | Composting | Build a scarecrow.
ThoGames	Cultural tourism activities | Create decorative objects with recycled materials (Elkington & Hailes, 1992) | Create dream catchers | Puzzle construction | Didactic games.

4. Expected results

Several studies have shown that when someone wants to change or invest in a society, he or she should start with the youngest segments of the population as these are not yet "formatted". It is easier to positively shape these "little heads", eager for knowledge and discovery. As DeJarnette (2012) argues, the lack of professionals in those fields of expertise should be combatted with an early intervention amongst first year/primary school students. Research has shown that early exposure to STEM (Science, Technology, Engineering and Math) initiatives and activities positively impacts elementary students' perceptions and dispositions. They will be the engine that will transmit knowledge to whom they relate to and later, as adults, they themselves can make decisions and intervene positively in society.

The ACAP's results were extremely positive, as can be seen in Figure 2. These observations underline the broad impact of science camps on the participants. This can be illustrated by a quote from one of the ACAP organisers: "these initiatives and experiences are extremely important for children mainly because they create relationships and increase interest in sciences, as well as enabling them to be free to express themselves". This is in line with Lindner (2014).

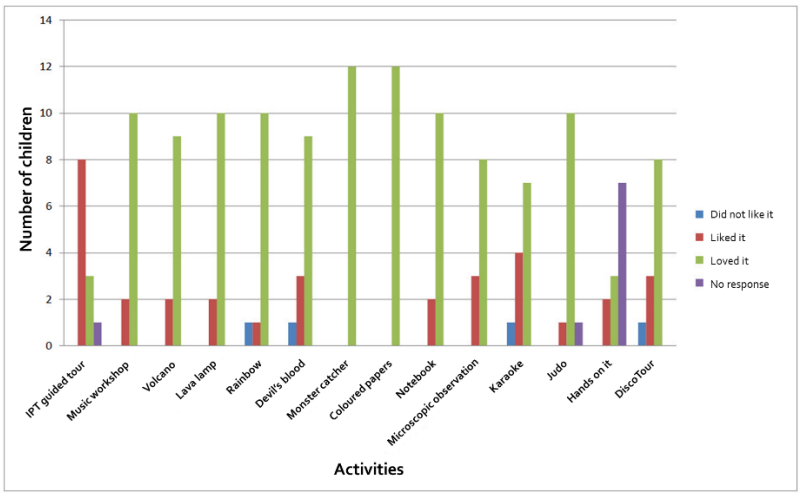

Figure 2. IPT Children's responses to the activities enquiry, Christmas 2013 edition.

In the first place children's pre-registration numbers always exceeded the number of places available. So the ACAP tried to provide a higher number of activities for each next edition. Unfortunately, due to a shortage of staff and an increase of departmental projects, it was not possible to maintain such large numbers of children for each edition (a maximum of 42 distributed over two weeks of activities in Easter 2014, as shown in Table 2), necessitating their being reduced to a maximum of 20 to 24 for the 2015 editions. All activities are publicised on the web page and also on Ângulo Magazine (http://www.cph.ipt.pt/download/AnguloDownload/revista/Revista_2_Angulo.pdf).

Table 2. List of ACAP editions versus participants' ages and total children.

Academy editions (number of working days)	Christmas 2013 (3 days)	Easter 2014 (10 days)	Summer 2014 (15 days)	Christmas 2014 (3 days)	Easter 2015 (5 days)	Summer 2015 (10 days)
Children born in 2007	-	3	1	3	5	3
2006	1	7	6	5	5	1
2005	4	11	5	7	2	8
2004	2	6	10	3	1	2
2003	4	9	11	6	6	7
2002	3	4	1	2	1	-
2001	-	1	-	-	-	1
2000	-	1	-	-	-	-
Children in Total	14	42	34	26	20	22

And second, there is an increasing interest from the children in the laboratory environment and an astonishing and unforeseen development of their skills, reasoning and motor dexterity capabilities. The group learning experience itself improved when, in the summer 2015 edition, an older group freely started to help youngsters overcome their difficulties. Hopefully this earlier intervention amongst children will motivate them to study the subjects in the fields of science, art, technology, engineering and mathematics and produce future professionals in these fields.

Additionally, relationships between faculty members, staff, and students increased and enriched with these workshops especially with a positive IPT contribution in helping student-monitors financially. Also some workshops were important for the development of others. As an example, glazed clay volcanoes were used in the chemistry lab to simulate volcanic eruptions!

Finally, there was increased interest and enthusiasm on the part of the parents as well as an obvious promotion of IPT's work and knowledge among the local population.

5. Conclusions

Since its inception in October 2013, the demand for the Academy's workshops by students, teachers and parents has been continuously growing, which proves that this type of projects is very much needed in Portuguese society. All pre-registration numbers in all editions have exceeded the number of places available. In the last edition, in the 2015 summer holidays, confirmed registrations (paid pre-registrations) sold out three weeks prior to the enrolment due date. The ACAP is constantly receiving parent's messages asking about opening dates and registrations.

The expectations created by the participants in relation to child supervision have been overwhelming. Due to very good personal relations established between all collaborators, teachers and children, a beneficial interaction between a university environment and its local population enabled the positive and increasingly higher development of children.

Two years since the start of this project, one can conclude that this is a consolidated successful project. The future challenge is to maintain the interest of the children who have accompanied us from the first edition. So far their interest has been maintained by the constant creation and introduction of new activities within the same subject to avoid repetition. Some of these children have grown with us and therefore there is a need to keep track of their maturity and adapt the activities to their growth.

A total of six editions have been accomplished so far with more on the way. Over the very last days of each edition, some children were very sad to leave the ACAP. Beyond what has been done and will keep on being done, the ACAP is now prepared for the next phase: to intervene more persuasively within the elementary (first-cycle) schools, in order to capture the interest of every child for learning.

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