



Hands-on Science

Science Education with and for Society

Edited by
Manuel Filipe P. C. Martins Costa
Pedro Miguel Marques Pombo
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The Hands-on Science Network

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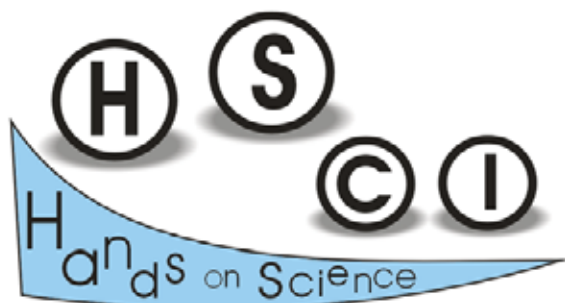
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Foreword

Science Education with and for Society

The decisive importance of Science on the development of modern societies gives Science Education a role of special impact.

Society sets the requirements rules and procedures of Education defining what concepts and competencies citizens must learn and how this learning should take place. Educational policies set by governments, elected and or imposed, not always reflects the will and ruling of Society.

The School as pivotal element of our modern educational system must look behind and beyond imposed rules and regulations and persistently seek a permanent and open relation with Society, in all its dimensions, assuming and defending its crucial role on the development of Society and humankind.

Aiming to contribute to an effective implementation of a sound widespread scientific literacy and effective Science Education in our Schools and Society at large, the Hands-on Science Network promotes a number of meetings and conferences open to the widest range of contributions on different pedagogic approaches with the common goal of promoting an effective learning of Science.

This book gathers a number of interesting works presented at the 11th International Conference on Hands-on Science held in Aveiro, Portugal, July 21 to 25, 2014. The different chapters covers a wide range of topics including different strategies on connecting school' science education with society and on synergetic relations between Society and Science Education, reports on good practices on formal as well as non-formal or informal science education, ICT tools, IBSE, active learning and hands-on pedagogy. We believe that the materials herein are a rather useful tool to assist teachers and educators as well as all interested in Science Education and its impact on the development of our Societies.

Vila Verde, Portugal, July 7, 2014.

Manuel Filipe Pereira da Cunha Martins Costa
Editor in chief

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Linking Science Garden to School and University: Teacher Education, Research and Dissemination

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Abstract. Science Garden [SG], located in the Department of Education at University of Aveiro [UA], is a non-formal science education context designed to promote children's explorations (4 to 12 years old). It offers challenges and outdoor exhibits focusing on key themes of Science – Forces and Motion, Light and Water. This communication aims to clarify SG's strands: education and dissemination of science and technology; research in science education; and teacher education.

Keywords. Education and dissemination of science and technology, teacher education, research in science education, articulation between school and a non-formal science education context.

1. Introduction

As an educational extension of the Open Lab for Science Education sited in the Department of Education of the UA, SG is a non-formal science education context (Fig. 1).

SG was conceived to promote the scientific culture of children with special regard to the collaboration with schools, as argued by Gadotti [1]. In this sense, it pursues the following strands which will be further detailed in this article, giving emphasis in the

last stated: education and dissemination of science and technology; research in science education in early years of schooling; and science teacher education.



Figure 1. Partial view of Science Garden

1. Presenting Science Garden

SG integrates outdoor and indoor settings offering hands-on, minds-on and hearts-on activities which seek to stimulate visitors to observe, question, preview, compare, analyse, connect and communicate.

In the outdoor setting, visitors are invited to explore an interactive exhibit with large devices focusing on the following key themes of Science: Forces and Motion, Light and Water (Table 1). The following were developed by the SG team: Look for the living beings; Bet on the faster marble; Control the water; and Find your image. In addition, SG presents Expression Boards where visitors may register messages about the field trip.

The indoor setting is called *Challenging workshop*. It has benches and tables where visitors are challenged to build, test and

explore devices, models and mechanisms with relevant scientific and technological knowledge, such as telescopes, kaleidoscopes, flat and curved mirrors, fly eyes' glasses (Fig. 2), magnetic marbles and puzzles and building blocks.

Forces and Movement	Water	Light
Go up with the least effort	Look for the living beings	Find your image
Test your balance	Bet on the faster marble	Find the rainbow
Ring the bell without effort	Control the water (Archimedes screw, Release the water and Water spin)	
Speed the wheel		
Spin the balls		

Table 1. Key themes of Science Garden and interactive devices

SG is placed in the Department of Education at the University of Aveiro [UA]. It opened to the public in December 2006.

2. Education and dissemination

In the scope of education and dissemination of science and technology, SG has been seeking to encourage the excitement of discovery, taste, curiosity and questioning among its visitors.

Since its opening until July 2014, it received about 5343 visitors, mainly children, besides adults.

There are two kinds of guided field trips for school children, chosen by their teachers or educators: general and customized.

The most requested ones are general visits which involve the exploration of all outdoor interactive devices and indoor science challenges in groups of up to 6 children.

When dealing with the interactive device and in order to overcome the science challenge, children are asked to: observe and describe the main scientific and technological features; predict what is going to happen based on concepts and principles of science and technology; discuss in group how they have felt and possible explanations for it; present examples of daily life where those concepts and principles acquire much importance.



Figure 2. Science Garden's visitor exploring fly eyes' glasses

Besides that, the SG team provides support for planning visits which are customized according to teachers' pedagogical objectives and pupils' school curriculum. So they are focused on the exploration of interactive devices integrating just one or two key themes of Science and/or the exploration of teaching resources developed by researchers and pre-service teachers. These teaching resources can be explored in the *Challenging workshop* or in the Open Lab for Science Education.

The SG team also provides the possibility to explore those teaching resources during events promoted by UA such as Junior Summer Academy (scientific occupation

programme for 10 to 12 year old children) and Science & Technology week (<http://semanaberta.ua.pt/pub/default.asp>). In the last edition of this event (18-22 November 2013), in the Open Lab for Science Education, primary school children were invited to explore 5 teaching resources about the theme *Discovering objects and materials*, adapted for this event. One example is the teaching resource *The journey of the materials: from raw material to object* where children were challenged to identify raw-materials, materials and objects, as well as to match them, using their senses and working together under the supervision of their teacher and a SG monitor (Fig. 3). SG also receives the visit of science education researchers, government technicians of education and science and technology teachers from around the world. Some guided tours are included in education programmes promoted by the Department of Education of the UA.

3. Research

Research has been showing that teacher resources focused on promoting scientific knowledge and skills which link classroom and non-formal science education contexts are desirable by teachers but scarce. In order to enlarge the offer, research projects have been developed in SG [2,3,4,5]. They involved the development of teaching resources that articulate SG and schools with activities before, during and after the field trip for primary school pupils, some of them including teacher education, as mentioned below.

Some products of research linking SG and school rely on Science, Technology and Society [STS] orientation [2,3,4]. For

instance, results obtained from teaching resources aiming at the promotion of critical thinking skills [8] showed that children who explored them had higher scores in post-tests appealing to critical thinking skills than the ones who didn't explore them.



Figure 3. Children exploring the teaching resource *The journey of the materials: from raw material to object*

Those research projects [3,4] were considered in the development of the collection "Exploring the Science Garden" by the SG team. It includes Teaching Guides to help teacher planning the activities before, during and after a field trip to SG. Each one is focused on a SG key theme: Water [6]; Light [7]; and Forces and Motion [8]. It presents activities for classroom (before and after the field trip) and for SG (during the field trip) and the associated curricular and conceptual frameworks. Other teaching research based resources are intended to lead to new Teaching Guides.

Furthermore, research [9] that relied on the development of teaching resources was conducted in order to improve science and mathematical skills on primary school pupils, in particular, related to problem solving and communication. The research provided

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evidence that most of the pupils improved those skills, especially, communication.

In its turn, research involving teacher education was also carried out. In the root of it there was evidence that teaching resources focused on STS orientation are desirable, yet scarce [10, 11], especially, for pupils in the early years of schooling [12] and in non-formal science education contexts [13], where the field trips can be one way to promote it [14]. Research involving the exploration of teaching resources with those features in SG showed different scenarios: it strengthened the STS pedagogical orientation of one teacher; introduced pedagogical innovation in the practices of another; and had no contribution to the reorientation of the third one.

To sum up, research that included the development of teaching resources linking classroom and SG activities has shown that they may promote scientific knowledge and skills in children attending early years of schooling, as well as favorable attitudes towards science,.

4. Teacher education

SG has been a pre-service and in-service kindergarten and a primary school teacher education resource, as described in the next second-order headings.

4.1 Pre-service teacher education

Pre-service teachers have field trips to SG with the support of their Professor and the SG monitor, when attending curricular units of the undergraduate course of Basic Education of UA. This Degree (1st Cycle Bologna - 3 years - 180 ECTS) aims at a broad-based professional training, both in

terms of employability as well as access to various 2nd cycle specializations (Pre-School Education, Primary and Middle School) which vary from 90 to 120 ECTS (Masters). Those field trips are driven as follows.

In the first year of the course, under the curricular unit of Integrated Natural Sciences the focus of the field trip is on concepts and principles of science and technology. After observing each interactive device feature, they are told how it works and the science challenge associated to it. Then, they are asked to predict what is going to happen when they experience it (whenever it is possible) based on scientific and technological knowledge and principles in action. Pre-service teachers aren't corrected for two reasons: it is intended that they share and discuss their predictions with each other and draw conclusions based on the observation and hands-on experience.

In the third year of the course, under the curricular unit of Didactics of Natural and Social Sciences the focus of the field trip is on didactics of science in a non-formal science education context. Pre-service teachers are told what they should consider when planning a field trip to SG, such as the educational offer of SG, how to book for a visit and safety rules. They also get to know how they should explore each interactive device. In addition, they are told how children may behave when exploring it, including the most common predictions and how they react to hands-on experience. This is important in order to anticipate children's behaviours. These learnings may be applied to other non-formal education contexts.

Such field trips may occur in different moments of the curricular units. It may be aimed to introduce scientific and technological content knowledge and skills,

presented later on, in classroom or to consolidate the already presented ones.

The SG field trips with pre-service teachers are conducted differently from the ones with school children: children explore interactive devices in groups of up to 6 people but the class of pre-service teachers do it together. In addition, they are only allowed to explore a few devices, like Speed the Wheel (Fig. 4) because not all are also dimensioned for adults.

Overall, in the field trips conducted under both curricular units, pre-service teachers are stimulated to explore hands-on and minds-on dimensions of the interactive devices. This is very important because they are expected to apply these learnings about science teaching in school and in non-formal science education contexts. In fact, some mobilize them when attending master courses both supporting SG field trips and/or planning field trips as teacher trainees.

4.2 In-service teacher education

In-service teachers have been participating in jardim.com/professores (Fig. 5). This is a session to help them planning and booking field trips to SG, considering school curriculum and programs and the articulation with classroom activities before and after the field trip, including a guided tour and presentation of the collection "Exploring the Science Garden".

Since 2012 there have been 5 editions. Those totalized 48 participants, the majority kindergarten and primary school teachers besides tutors and promoters of leisure activities. Most of them are from the centre and north of the country.

In the end of each session, participants are asked to fill in the "Questionnaire

garden.com/teachers", available online (<http://questionarios.ua.pt/index.php/14294>) about the session and the SG educational offer. In the last one, in September 2013, we obtained the following results from 18 participants. In the first question "As a professional of education register your general comments and or suggestions about Science Garden", all answers were positive, such us: "The visit was extremely useful to prepare school visits with precise details, but quite enlightening summary with explanations regarding the contents. Undoubtedly a place to explore!"; "The [Science] Garden becomes important for addressing scientific concepts... first on a non-formal context and subsequently an approach in the classroom."; "I think it is an excellent way to stimulate and awaken (in a playful way) children to science."



Figure 4. Pre-service teacher exploring Speed the wheel

In the second question "As a professional of education register your comments and or suggestions about the session you have attended.", also all answers were positive, for instance: "It was very interesting because

experiencing SG allowed the kindergarten teacher to schedule a field trip.” and “The session was very explicit and enlightening.”. The third question “After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of importance that you impute to” included the items presented in the following table (Table 2).



Figure 5. In-service teacher attending jardim.com/professors (garden.com/teachers)

The fourth question included the same items but with focus on the adequacy imputed by the inquired participants (Table 3). The overall results of the questions 3 and 4 of “Questionnaire garden.com/teachers” suggest that this edition was considered: “Very important” by most of the inquired participants in all items; “Very adequate” by most of the inquired participants in all items. In general, the session was considered positive, taking into account its importance and adequacy to planning a future field trip to SG with children.

After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of importance that you impute to	1	2	3	4	5
(a) the booking of the visit system;	0	0	5,26	89,47	5,26
(b) the support given to the visit planning;	0	0	10,53	84,21	5,26
(c) customized activities offer to be carried out during the visit;	0	0	5,26	89,47	5,26
(d) the support given in linking science activities in formal (e.g. classroom) and non-formal settings (e.g. SG);	0	0	10,53	84,21	5,26
(e) the collection “Exploring Science Garden”.	0	0	21,05	73,68	5,26

Subtitle: (1) Very little important/ no important; (2) Little important; (3) Important; (4) Very important; (5) No answers.

Table 2. Results (%) of the Question 3 of the online questionnaire

After your participation in this session and considering the possibility of a future field trip to SG with children mark the degree of adequacy that you impute to	1	2	3	4	5
(c) the booking of the visit system;	0	0	26,32	68,42	5,26
(d) the support given to the visit planning;	0	0	26,32	68,42	5,26
(c) customized activities offer to be carried out during the visit;	0	0	26,32	68,42	5,26
(d) the support given in linking science activities in formal (e.g. classroom) and non-formal settings (e.g. SG);	0	0	10,53	84,21	5,26
(e) the collection “Exploring Science Garden”.	0	0	31,58	63,16	5,26

Subtitle: (1) Very little important/ no important; (2) Little important; (3) Important; (4) Very important; (5) No answers.

Table 3. Results (%) of the Question 4 of the online questionnaire

5. Conclusion

As shown, SG is giving evidence of its contribution to support education and dissemination of science and technology among young visitors, research in science education and pre-service and in-service teacher education. Still, there is much to do in order to reinforce the investment in these strands that make SG unique. Overall, SG intends to continue promoting the articulation between school and non-formal science education contexts.

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Hands-on Science

Science Education with and for Society

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Author Index



- Aibéo A 113
Albergaria Almeida P 283
Almeida Aguiar C 195, 386
Almeida AM 444
Almeida MJ 386
Almeida P 295
Alvané T 231
Alves A 319
Andrade V 82
Anjos S 113
Azevedo C 87
Baioa A 50
Banerji N 13
Baptista M 82, 289
Barata S 295
Bastos G 160
Belaga V 404
Berezina S 61
Bezerra A 393
Blajé J 358
Blanco García J 144
Boal Palheiros I 452, 456
Borges de Carvalho N 231, 431
Borges R 50
Bormashenko E 200
Branco S 270
Brito R 388
Burri S 160
Caldeira H 365, 375
Carramat LFND 226
Carvalho A 348
Castro IFC 226
Çavuş M 463
Coimbra N 267
Conde T 452
Correia M 333
Correia PMM 226
Costa JA 160
Costa MFM 3, 33, 42, 72, 188
Costa R 215
Cuba Guerra OA 200
Cunha A 420
Cunha L 137, 235, 386
Dale Tunnicliffe S 68
Dias C 17, 207, 354
Dias H 393
Díaz Lobo M 219
Domínguez JM 259
Doran R 175
Dorrío BV 13, 144
Erol M 463
Faria S 309
Fernandes E 207
Fernandes SB 160
Fernandes Soares AX 431
Fernández Novell JM 219, 358
Fernández Oliveras A 180
Ferreira A 309
Ferreira B 380
Ferreira F 420
Ferreira JA 211
Ferreira S 348
Ferreira Y 436
Festas I 365
Figueiredo de Andrade V 289
Fonseca A 369
Fonseca MJ 171, 207, 354
Forjaz MA 386
Freire Aleixo AM 195
Freitas D 420
Gabriel B 408
Gandarinho A 301
Garcia J 324
Geraldes MC 276, 470
Gil V 375
Gomes S 369
Gonçalves S 270
Gregorio Montes A 250
Guimarães L 333
Jacinto J 452
Jangir S 97
Jordão N 365
Kazachkov A 29, 200
Kireš M 29
Kochnev P 404
Kothari A 97
Kothari K 97
Krejci J 109
Larsen K 333
Leal JP 414
Leal S 414
Leite D 420

Leite I 235
Lin CL 54, 239
Lin JC 54, 239
Lobato Costa J 215
Lopes B 160
Lopes Cardoso PC 231
Lopes M 331
Lopes R 452
Lopes S 270
López R 87
Machado A 423, 436
Machado AF 276, 470
Machado C 215
Machado P 72
Maciel M 386
Magalhães MC 160
Malheiro MT 246
Marques A 452
Marques AR 289
Marques M 42
Martinho M 283
Martinho R 184
Martins A 171
Martins V 188
Mendes A 160
Mimoso L 452
Mina IAP 444
Mkaza N 404
Monteiro A 388
Moreira A 87, 382
Mota PG 388
Moutinho LM 226
Mutlu S 463
Neto V 408
Nobre A 386
Nogueira S 338
Norberto Ferreira AB 444
Nunes H 87, 382
Oliveira de Azeméis M 160
Oliveira L 423, 436
Oliveira P 369
Oliveira S 215, 452
Oliveira, D 226
Oliveras ML 180
Ornelas P 160
Pacheco J 420
Paiva J 211
Palhas J 319
Panebrattsev Y 404
Pavlickova L 103
Peixoto E 369
Pereira B 452
Pereira I 452
Pereira J 160
Pereira S 129
Pinheiro LCS 276, 470
Pinheiro MJ 331
Pint A 235, 386
Polcin D 61
Pombo P 295, 331, 346
Potrebenikova E 404
Prado X 259
Quintino V 331
Rabaça L 315
Ramos A 369
Rei M 235
Reis P 289
Resende V 160
Resende F 267
Ribeiro ACP 226
Rodrigues AM 319, 331
Rodrigues AV 338
Sá CM 99
Saiote J 333
Santiago A 436
Santiago AJ 276, 470
Santos A 165
Santos E 346
Santos L 99
Santos TM 380
Santos-Carvalho A 348
Saraiva J 160
Schreck Reis C 87, 382
Seixas S 301, 309, 324
Sena Esteves J 393, 396
Sepúlveda J 393, 396
Serra F 33
Shieh FY 54, 239
Sidorov N 404
Silva A 420
Silva ALM 226
Silva C 388, 436

Silva CE 276, 470
Silva D 423
Silva Jorge FM 231, 431
Silva L 423
Slabeycius J 61
Sousa E 319
Stetsenko M 404
Stoddard D 13
Tavares AC **19**
Tavares F 171, 207, 354
Tavares Jr AD 276, 436, 470
Teixeira J 319
Teixeira-Dias J 283
Tinoca L 289
Trincão P 87, 382
Trna J 103, 152
Trnova E 109
Vale D 165
Varela 3, 33
Vasconcelos V 333
Veloso JFCA 226
Viegas A 160
Vieira AP 160
Vieira RM 338
Vieira V 129
Vladescu E 400
Vladescu LC 440
Washington M 423
Yilmaz I 463
Zaragoza Domènech C 219, 358

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