Association of Science and Technology Centres

International study of Science Centres' contributions to development of youth professional skills

National Report, Portugal

Carlos Catalão Alves

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1. Introduction

1 List of national contributors:

Table 1.
List of Participants in the focus groups

Gender	Function	Institution	Profile
F	Teacher	Pedro Jacques de Magalhães School	Natural Sciences teacher
M	Teacher	Almada Professional School	Physics & Chemistry teacher
F	Teacher	Dom Francisco Manuel de Melo School	Natural Sciences teacher
F	Teacher	Planetário Calouste Gulbenkian – Centro Ciência Viva	Physics and Chemistry teacher currently coordinating the education unit of a science centre
M	Entrepreneur	*Indra Company* Dedicated to Financial Services, Energy and Utilities, Security and Defense, Transportation and Traffic, Public Administration and Health, Industry and Commerce and Telecommunications	Director of Public Administration market
M	Entrepreneur	*LusoSpace* Dedicated to the development of technological systems and components for the Space Industry.	Managing Director
M	Science Communicator	Centro Ciência Viva do Lousal	Director of a Science Centre and Geology researcher at Lisbon University
M	Science Communicator	Pavilion of Knowledge – Ciência Viva Science Centre	Project manager at the Scientific Culture and Outreach Unit of a Science Centre
F	Science Communicator	Pavilion of Knowledge – Ciência Viva Science Centre	Director of the Department for Education and Scientific Culture of a Science Centre
M	Science Communicator	Fábrica – Ciência Viva Science Centre	Director of a Science Centre and Physics Professor at Aveiro University

1.2 Executive summary

Two focus groups were held at the Pavilion of Knowledge – Ciencia Viva, the largest Science Centre in Portugal, on a Saturday morning, 9th May 2015.

Participants were invited as representatives of three stakeholders groups, respectively from science communication, education and industry. Each focus group included five participants, with gender, affiliation and geographic balance.

Participants had no previous knowledge of the 11 statements under discussion. After an induction in which participants were informed about the goals of the present study, a letter of consent was signed by each acknowledging the terms of their participation.

Both sessions were video recorded as an added support to further analysis and reporting. The focus groups were moderated by the author of the present report, Carlos Catalão Alves, member of the Board of Directors of Ciência Viva, who designed the methodology, script and exercises. The preparation of all the logistics associated with the organization of the focus groups was carried out by Gisela Oliveira, a senior project manager from Ciência Viva, who acted also as an assistant and note-taker in both sessions.

A qualitative analysis of the outcomes of both focus groups, based on the participants oral and written account of their views, ideas and opinions about the statements under discussion, as well as on the video records of the sessions, provided the following brief presentation of their key conclusions. According to the participants' individual accounts and group consensus:

- Science centres may offer a contribution to the development of youth professional skills, particularly in terms of transversal skills such as observation, critical thinking, team work and inquiry. However, the quality and scope of this contribution rely heavily on museums and science centres' ability to draw meaningful collaborations with school science and formal education.

- The main advantage of science centres in the provision of learning environments rests on the effectiveness of their multi-sensorial interactive exhibits and programmes to raise students' interest, curiosity and excitement for science, and to improve their attitudes towards science and technology.

- In their efforts to attract young people to science-related professions, science centres should go beyond the provision of career information and counselling, by emphasising student participation in real scientific work, alongside science and technology practitioners, as part of solid partnerships with scientific institutions, universities and industry.

- Partially because science centres not subject to the same time and space organizational constraints as schools, and do not have to structure their activities within subject matter requirements, they may have an advantage in the development of more transversal skills. However, if they seek a longer term impact of the outcomes of their informal learning

activities, science centres must learn from schools their ability to organize and provide long standing skills that are essential to everyday adult life.

- Museums and science centres should reinforce their links with their local communities, acting as effective environments for social, economic and cultural development, involving key actors in these areas, particularly in civil society and research organizations, education, policy-making, business and industry, as a backbone strategy to increase the effectiveness and long term impact of transversal skills.

Chapter 1
National Policy on STEM Education and the Role of informal learning in Science Centres

1.3 Brief description of STEM-education in Portugal and of the role that science centres play in STEM-education.

Around half of all 25 to 34 years-old, in Portugal, still lack an upper secondary education. But to recent OECD data, these indicators have been improving, particularly from 1995 and 2010, where Portugal showed the highest increase in upper secondary graduation rates (4.7%), when compared with the OECD countries' average for the same period (0.6%). As far as higher education is concerned, in the OECD countries, in 2010, an average of 44% of all graduates from Bachelor's programmes or equivalents finished their degree. In Portugal more than 60% of all graduates have completed this type of programme.

STEM Education

- In the first cycle of basic education (1st to 4th grade), students have Mathematics as mandatory discipline, as well as Study of the Environment, which includes some notions of Botany, Zoology, Geology and Astronomy.

- In the second cycle of basic education (5th to 6th grade), students have Mathematics, Technological Education and Natural Sciences as mandatory STEM disciplines.

- In the third cycle of basic education (7th to 9th grade), students have Mathematics, Technological Education (only in the 9th grade), Physics/Chemistry, Geography and Natural Sciences as mandatory STEM disciplines.

- In secondary education (10th to 12th grade), students have access to the following STEM disciplines: Mathematics, Biology, Geology, Physics, Chemistry, Descriptive Geometry and Geography. Nevertheless these disciplines are not mandatory for all students: depending on the course they choose, they will have different disciplines. For example, there are three different Mathematics' disciplines for secondary education students, depending on their courses (natural/exact sciences, technological studies or social sciences).

STEM Initiatives and the role of Science Centres

Portugal has been particularly active in initiatives and enrichment programmes aiming at promoting science education in schools and raising young people interest for science and scientific careers. With these goals in mind, a pedagogical reform on STEM has been implemented in Portugal for the last decade, with a great focus on partnerships between science centres, schools, universities, scientific institutions, municipalities, etc. Accordingly to Horta (2013), this reform has been addressed by key initiavesing:

- standardization of STEM curricula in primary and upper secondary education: curricular reform, national action plan for mathematics and technological plan;

- supplying qualified STEM educated teachers: technological plan; experimental teaching; *Ciência Viva*;

- preparing pupils and students for post-secondary STEM study: *Ciência Viva*;

- motivating students for STEM: *Ciência Viva,* technological plan, Olympiads, Ethnomatematics, mathematical plan;

- enhancing the number of graduates in STEM via science and technology policy development.

Because Ciencia Viva – the Portuguese National Agency for Scientific and Technological Culture – is the body that encompasses a nationwide network of 20 science centres – the Ciência Viva Science Centres, this report will focus mainly the characteristics of the STEM initiatives promoted by this Agency, for these have a strongest involvement of science centres across the country. Here are two concrete examples (Catalao Alves, 2011).

> *Funding and support schemes for science projects in schools.* This programme, *Science at School*, has been carried out systematically since 1996. This initiative, which has reached a thousands of students, teachers and scientists, is designed to help reinforce the relationship between the scientific and educational communities, through sharing resources and knowledge and promoting dialogue, with a strong involvement of science centres. Its main goal is to promote solid and sustainable links between schools and scientific institutions through science education projects. The participation of higher education and polytechnic institutions, research centres, associations and scientific societies has been providing technical support and scientific and pedagogical education for elementary and secondary teachers and pupils.
>
> *Summer Science Internships for Secondary School Students.* This is the most extensive on-going science internship programme for secondary school students in Europe. It is designed to promote science learning through work experience and attract young people to careers in natural science and technology. The extent and impact of this type of science workplace learning is demonstrated by the increasing number of junior and senior secondary school students learning science in university and industry research facilities under the mentorship of science and technology practitioners. An annual average of 70 research and higher education institutions receive up to 1000 secondary school students for internships during summer holidays. Activities are centred in practical research carried out alongside professional science and technology practitioners at their workplace (Catalao Alves, 2012).

1.4 Museums and Science Centres in Portugal

The social expectations of the modern societies are putting extra pressure on science centres and science museums. In Portugal, over the past decades, the expansion and renovation of science

museums have been considering the physical reality of their installations as a multi-sensory engaging experience that is more in tune with the world we live in. Portuguese science centres are also undergoing dramatic changes in the design of their mission statements. The focus on hands-on displays about scientific principles and phenomena is being shifted towards an emphasis on involvement, dialogue and activity.

Science centres in Portugal are increasingly becoming active platforms for social, economic and cultural development, involving some of the most dynamic actors in these areas. This means, above all, creating multiple partnerships with organizations that are bound to share efforts and enhance their collective impact. In Portugal, for example, this is being achieved by local agreements involving science museums, city councils, universities and science research centres and institutions. Such a strategy was the backbone of an expansion process leading to the creation of a network of 20 science centres.

Table 2.
Portuguese Museums and Science Centres

Title	Themes	Venue (city)
Centro Ciência Viva de Lagos	Astronomy and Maritime Discoveries	Lagos
Centro Ciência Viva do Alviela	Geology	Alviela
Centro Ciência Viva de Proença a Nova	Environment	Proença a Nova
Centro Ciência Viva de Bragança	Energy and Environment	Bragança
Centro Ciência Viva de Sintra	Human body	Sintra
Planetário Calouste Gulbenkiana	Astronomy	Lisbon
Centro Ciência Viva de Estremoz	Geology	Estremoz
Centro Ciência Viva de Tavira	Water and Energy	Tavira
Centro Ciência Viva de Porto Moniz	S&T	Porto Moniz
Fábrica de Ciência Viva	S&T	Aveiro
Centro Ciência Viva de Constância	Astyronomy	Constância
Pavilhão do Conhecimento - Ciência Viva	S&T	Lisbon
Exploratório Infante D. Henrique	S&T	Coimbra
Centro de Ciência Viva do Algarve - Faro	The Sun	Faro
Planetário do Porto	Astronomy	Oporto
Centro Ciência Viva de Vila do Conde	Water	Vila do Conde
Visionarium	S&T	Vila da Feira
Museu de Ciência da Universidade de Coimbra	S&T and History of Science	Coimbra
Museu Nacional de História Natural	Natural History	Lisbon
Centro Ciência Viva do Lousal	Mining	Lousal
Centro Ciência Viva Rómulo de Carvalho	S&T	Coimbra

Chapter 2
Outcomes of the Focus Group

2.1. Introduction

Two focus groups (FG) were held at the Pavilion of Knowledge, the largest science centre in Portugal and head of a national network of 20 science centres – National Network of Ciencia Viva Science Centres.

Both focus groups were moderated by Carlos Catalao Alves, a member of Ciencia Viva Board, and assisted by Gisela Oliveira, senior project manager at the Pavilion of Knowledge.

The introduction followed ASTC recommendations and protocol, namely by presenting the goals of the focus group discussion, the overall research design, the nature of science centres and their role as informal science learning environments.

The protocol was followed in all instances, participants in both focus groups had no previous contact with the statements under discussion, and they all signed a consent letter with the terms of their participation.

To make sure that all voices were heard within e context of a sound debate of ideas, with multiple stances and viewpoints, the following methodology was presented, agreed by and followed by the participants (see Table 3).

Table 3
Discussing of the 11 statements

For each statement under discussion, participants were invited to voice their input by writing their views and opinions in two types of cards: a green card for arguments in line with the statement, and a yellow card to express a more critical position in relation to the same statement. The cards were then used to guide the discussion. At the end of each statement, the moderator wrote in a flip-chart, following the consensus of the group, one or two sentences summing up the key conclusions for that statement.

After the discussion of the 11 statements, the flip-chart sheets with the group conclusions were assembled in the board for a final exercise: the prioritization of the conclusions. The exercise went as follows: each participant was given a dozen of red sticks and invited to distribute them to vote on the

key conclusions of their choice (this was done all at the same time to avoid any kind of peer influence).

Finally, the key conclusions that received the largest number of red sticks were then subject to a final discussion to get the overall consensus of the group (see Table 4).

2.2. The 11 statements

The following items sum-up the key arguments express by the two focus groups, with reference to specific stakeholders' perspectives – teachers and educators (TE); science communicators (SC); nosiness and industry (BI).

Arguments are distributed by each of the 11 statements under analysis, including some of the participants' key ideas, written by themselves in the cards that they had available for that purpose. These help to underline participants' view-points expressed in their own terms.

S1 - We should let children just enjoy science centers, not turn centers into schools

The idea of complementarity is a common concern across all stakeholders: both formal and informal approaches are seen as particular traits of science centres. However, the Science Centres' stakeholders group is more likely to put the accent on their ability to trigger curiosity and engagement from the wonder-like environment that is so characteristic of science centres. For them, this is a trait that should not be underestimated by turning SC into school-like environments.

Key participants' ideas
TE – Children should be driven to discover science in a playful manner
SC – Science centres are a complement to other learning approaches
BI – I agree [that we shouldn't turn centres into schools] because it would mean a repetition in diverse environments and contents. Centres should complement school and formal education
SC – These are complementary experiences and, therefore, these represent an added value. By promoting "unguided discovery" we increase the motivational drive.
TE – I agree. When take my kids or friends to the science centre it is important that children benefit from that informal environment and realize that it is an alternative to learning in school.
BI – We learn better if the indicative to explore is driven by the visitor.

The Formal Education stakeholders' group endorses this view, and takes it to an almost radical stance: SC should never be turned into schools – they should put the accent on the motivational drive and provide the kind of environment that school science is missing to address. Industry stakeholders, on the other hand, are more demanding in this regard and advocate the role of science centres as practical skills providers, in line with their hands-on philosophy.

S2 - Science centers work better for boys than for girls

All stakeholders share a common disagreement in this respect. Science centres, in their view, serve both boys and girls needs and expectations. Nevertheless, for the industry group, the fact that science centres rely heavily on hands-on strategies, particularly in more "male-like" subjects, like computing, engineering and physics, render them more effective for boys.

Key participants' ideas

TE – I do not have that perception at all [of science centres working better for boys than for girls]

SC – I do not agree [that science centres work better for boys]. It depends on the individual and not on the gender.

BI – Boys need to move around more and manipulate things with their hands

TE – Depending on the activities, some might influence or trigger more interest from boys, as for girls.

S3 - Schools can learn more about teaching science from science centers than the other way round

Science Centres are seen as more appropriate for inquiry-based teaching, not only because they deliver the kind of practical work that is missing in basic school science, but also because they are seen as providing the type of authentic scientific tools that are absent in many school laboratories. This view is particularly endorsed by industry and school stakeholders, whereas the science centre group is less likely to share this perspective.

Key participants' ideas

TE – For schools, science centres represent an opportunity of contact between teachers and scientists with the goal of improving the quality of student learning. They are also [science centres] teacher training centres and, therefore, places of excellence for professional development.

SC – Schools may "gain" a lot from the advantages of informal learning, particularly in terms of

student motivation and soft skills..

BI – Boys need to move around more and manipulate things with their hands

BI – Yes [schools may learn more from science centres] because they isolate disciplines too much.

S4 - Science centers should not promote science careers - that's not their job

Most participants discard the perspective of promoting scientific careers as being a key mission of science centres, particularly if it is seen from a marketing stance. Attracting youngsters to science, or to science-related careers, should not be equated to promoting careers – a task that should be left to universities and other higher education institutions, which are seen as better equipped for such a purpose.

However, there is a consensus about the need to inform the public about the specific characteristics of scientific careers, especially as far as the processes and impacts of science are concerned, leaving out the job profile and the life project aspects and, ultimately, the information about wages or career perspectives.

Key participants' ideas

SC - Science centres should restrict their action to knowledge and information. They are not markets and showcase of professional "vanity".

SC - That [promoting careers] is also their mission: science is much more than knowledge.

SC - Because [science centres] stimulate curiosity and provide contacts with scientific culture, it is only natural that they trigger a motivation to pursue a scientific career

BI - It is important to showcase what it means to be a scientist or an engineer, particularly for those who are already attracted to these careers.

SC - Science centres should not be seen as advertising agencies for scientific careers.

TE – [Science centres] should promote above all scientific culture, because it is essential for citizenship. But it is also important to promote science career, since these are key in modern societies.

S5 - Science centers rarely focus on the relationship between science and industry

All participants recognize that science centres are not doing enough to explore the connections between science, business and industry. For the science centres stakeholder group this is a consequence of the focus being set in the school target, which leaves out their scope other key sectors of society. Stakeholders from the private sector are particularly bold in this respect, calling up for a shift on the attitude of science sectors towards industry. An interesting point being raised is that practical examples of scientific principles should be favoured in order to make clear how different it is when it comes to real applications in the field – particularly due to the need to guarantee the quality and robustness of these applications. School participants in both groups recognize however that some science centres do explore the relations between science and its real-world applications, even if not necessarily through explicit industry-related exhibits.

There are exceptions, most participants say, and that depends on the context of each science centre, on existing partnerships or, in some cases, on the involvement of industry representatives in their board of trustees and other science centre governance instances.

The point to retain, as unanimously expressed, is the absolute need for a shift of attitude in this regard: science centres must put the connections between science, business and industry at the top of their agendas.

Key participants' ideas

SC - Yes, they do not [explore those connections] because they are still more turned to schools than to society as a whole.

SC – That is not my perspective, even if that [exploration] doesn't come from a specific exhibition. There is a tendency to focus on applied sciences, for that will bring us closer to the public.

SC - It is a result of the absence of real links between science centres and industry.

BI – It doesn't have to be this way, and it will hardly go on being as such.

TE – I have visited some exhibitions that explore, but it doesn't happen often. It depends on each science centre. The more contextualized in this aspect make a direct connection to applied science.

BI – Yes [science centres should explore further the connections with industry]. They should have more practical examples on how application in the field might be different due to quality and robustness

S6 - Students acquire skills in science centers which are highly beneficial for their lives after school.

Both groups unanimously endorse this statement. Observation skills, curiosity, inquiry-related behaviour and interdisciplinary attitudes are seen as soft skills in which science centres take the lead. School representatives were particularly assertive in this respect, because science centres are not subject to the same time, space, curriculum and organizational requirements that we often find in school. However, industry stakeholders tend to have lower expectations from the ability of science centres to promote soft skills. For them, it is not a matter of general principle but rather one of context. Here, the effectiveness of science centres relies heavily on their ability to link soft skills to actual specific competences, mainly by reinforcing formal-informal collaborations and bridging the gap with industry real-world expectations.

Participants from science centres and schools, in particular, feel that the impact of these skills is very much dependent on the frequency of the exposure. Often, one school visit is not enough to nourish and develop the kind of skills and competences that are required for students' lives. In this respect, schools may have an advantage in forging the skills that are essential to lifelong learning.

Key participants' ideas

TE – Visiting a science centre is the kind of experience that "moves" the students: knowledge and skills go way beyond the school boundaries.

TE – That is one of the most important added-values of science centres.

SC – As anything else in live, skills come from intense training and continuous exposure. Too often, visits (especially from schools) are single occurrences, with no continuity, and their impact is likely to fade in time, if not properly nourished.

BI – Time spent in a science centre is too short for skill development.

S7 - Most science centers don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society

Science centres are more effective as drivers for knowledge society, when compared with their impact in creativity and innovation - this is a common view among participants in both groups. The reasons being that science centres remain too traditional in their approaches: content is often pre-defined during exhibition development t, which limits substantially the margin for creativity and innovation from the users/visitors.

For some, visitors should be stimulated to participate more in the design of content, tools and activities at the centre, for this would enhance the scope for creativity. Participants from industry

recognize that science centres may have something to learn from universities (and even some schools) in matters of innovation and creativity.

For others, there is scope for improvement in this area, as long as science centres are more visitor-centred, more attentive to visitors' individual traits and, also, more reflexive and creative in the use of their own resources.

Key participants' ideas

SC – Promoting creativity and innovation is time-demanding, something that science centres do not have … besides, a stronger connection to industry is missing all together.

SC – Information is not the same thing as knowledge. The promotion of creativity requires a stronger engagement from the visitor.

BI – Science centres rely too much on exhibitions

SCH – They [science centres] could do more with their own resources. They lack the kind of reflexivity that would help them to improve these aspects.

SCH – Diversifying methodologies would help those students whose characteristics are less conventional (say, for example, more artistic students).

S8 - The soft skills that one aims to achieve are important, but these can also be reached via other (extracurricular) activities like sports, arts appreciation etc

Participants in both groups agree with this statement. However, some – particularly from schools and science centres – believe that there are soft skills, such as team work or sound competitiveness, where sport activities take the edge, whereas critical thinking and inquiry, for example, are best served by science centres as informal science learning environments.

Industry stakeholders tend to insist in the need for complementarity between soft skills and subject-related competences. School representatives, on the other hand, disagree with the fact that soft skills may be developed in the same way by other activities, like sport or art-related activities. For them, the context in which soft skills are developed is essential for their application in similar contexts. Therefore, once the theme or topics are not similar, soft skills are not framed or contextualized in the same manner, and their impact is not likely to be the same in different kinds of activities.

Key participants' ideas

SC – All areas are important and should be worked out as a whole. Science promotes mainly the ability to question and explore in ways that are different from other areas.

BI – For some people, it is important that these [soft] skills are acquired in the field of science, for it is likely to have an enormous impact in their professional lives.

BI – Science does not have the monopoly of these skills!

SC – I agree. It depends on the approach and methodology. Different areas work different soft skills in different ways.

SCH – I agree, but soft skills have different values depending on the context in which they are acquired. Developing skills in a science learning environment is very enriching.

S9 - Focusing on the soft skills in schools will lower the results in test scores by taking time away from tested skills. That's where science centers can play a role

There is a consensus about the role that science centres may play as environments that help the development of skills that are not assess by school exams. Participants from schools expose this view of an on-going pressure to meet the demands of exams, and how it jeopardizes the acquisition of soft skills: the "time" factor plays against it, and that is where science centres may come to the rescue.

Key participants' ideas

SC – It might be necessary to rethink teaching and assessment in order to favour transversal skills, which are not less important. Science Centres will only be able to fulfil that role if school visits are increasingly promoted.

SCH – Yes [science centres may play an important role], because schools need time to "train" for exams.

SC – Even though science centres might have conditions for the development of soft skills, their role is irrelevant if schools and society fail to assume it.

BI – I agree [science centres may play an important role]. There has to be a clear distinction between schools and science centres, respectively for subject matter and transversal skills

However, while recognizing the advantages of informal learning environments to address transversal skills, participants also realise that the absence of assessment of the outcomes of informal learning has a double negative effect. On the one hand, because that is no evidence of success or failure, informal learning activities do not have the required indicators for improvement. On the other, because soft skills are not subject to assessment – both in schools and in science centres – there is a tendency to underestimate their value.

As a consequence, as other participants point out, the role that science centres play in soft skills depends effectively on the value that the formal education system attaches to those skills. If these are undervalued, as demonstrated by the absence of their formal assessment, the role of science centres is clearly undermined, no matter how equipped they are for the development of soft skills.

S10 - Visiting a science center has little impact on whether students follow careers in STEM

Science communicators tend to acknowledge the impact of science centres in the choice of STEM careers, but at the same time express the idea that the effectiveness of that impact might decrease as visitors grow up.

Teachers also favour the idea that visits to science centres must begin at an early age, which will, in their opinion, enhance the impact of these institutions on the choice of a career.

Industry participants recognize that visits to science centres may attract youngsters to STEM careers, but they point out that there are other important factors influencing that choice, particularly from family or peers.

There is still a lot be done in this area - that is the overall feeling among all participants in both groups. Some recommend a stronger investment in summer enrichment programmes, while others favour the proximity to more authentic science environments, with closer partnerships with the scientific community in real-world science projects.

Key participants' ideas
SC – Science centres work as a motivation drive, explore natural curiosity, favour a closer contact with real science and the scientific community, and in so doing induce the love for science and eventually for science-related careers. *SCH – No [science centres have no impact in the choice of STEM careers]. Other factors also play an important role.* *BI – Parents and society have a more influential role [in the choice of STEM careers].*

S11 - Science centers do trigger the attention of children, but do not invest in learning processes with real long term impact

There is an overall feeling among all participants that science centre are not designed to invest in learning processes with real long term impact – because that is not their mission, because that is what schools are made for. Science communicators tend to look at science centres as environments designed for "short term" activities, with a focus on triggering interest and excitement.

Likewise, teachers see the mission of science centres as one of attracting young children to science, leaving to schools the development t of learning processes with long term impact, since these explore learning outcomes that are already consolidated, rendering these more effective for lifelong learning.

Participants from industry also tend to look at science centre activities as being "too shallow", even if some recognize that attention is in itself a factor that might enhance learning to a degree that is not always reached at school.

On the other hand, some science communicators refuse the idea of science centres as learning environments designed to boost children interest and excitement towards science, since these also promote continuous professional development, long duration workshops, summer enrichment programs, and other kinds of activities with expected long term impacts. But they also recognize that there is still room for improvement in many science centres.

Key participants' ideas

SCH – [Science centres] are not only about catching children's attention, they have a wider influence, because attention is a determinant process for learning as a whole.

BI – Attention may raise retention [of learning] to higher degrees than schools.

SC – Subject matter addressed in science centres is just of an introductory nature, with a short lived span.

BI – I agree [that science centres do not invest in long term learning]. Maybe that is not the mission of science centres.

Chapter 3

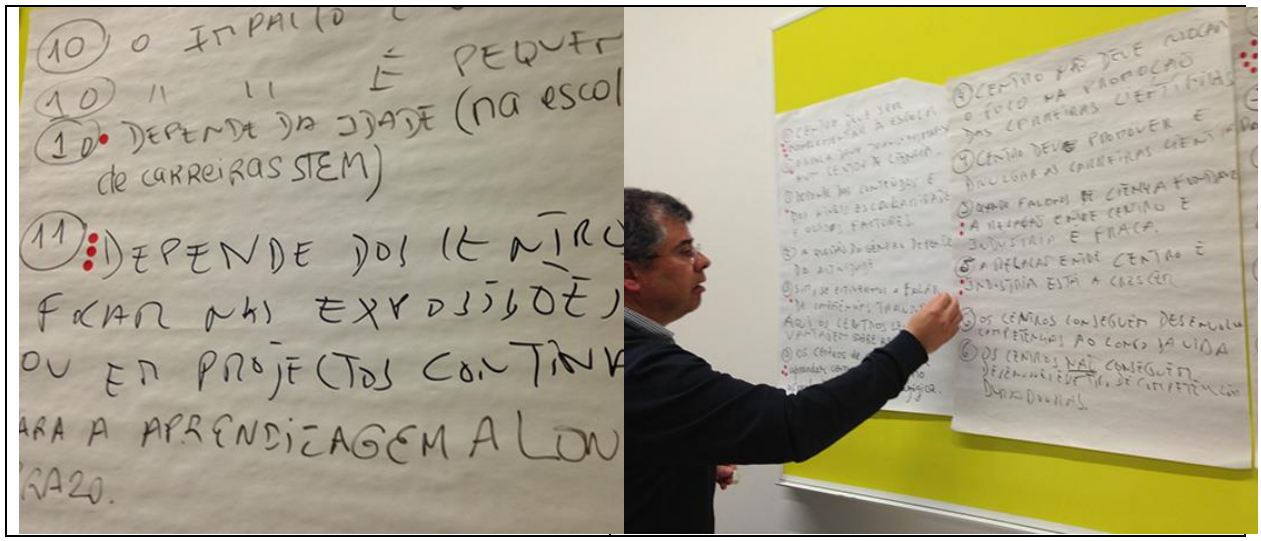
Conclusions

3.1 Conclusions per statement

As already mentioned, for each of the 11 statements, participants drew collectively a number of key conclusions. With the guidance of the participants, the moderator wrote these conclusions, statement by statement, in several flip-chart sheets, which were then displayed across the walls.

At the end of the session, participants had the opportunity to cast their vote. They did it by signalizing the conclusions of their choice with red circles, as shown in Table 4.

Table 4
Conclusions and prioritization of findings



What are now reported below are the conclusions which were prioritized and got the consensus of all the participants in both focus groups (Table 5):

Table 5
Conclusions in both focus groups for each statement

No	Statement	Conclusions
1	*We should let children just enjoy science centers, not turn centers into schools*	Science centres provide the kind of informal science learning environment that may offer a complement to school science, particularly in terms of raising students' interest, curiosity and excitement for science. This is a specific trait of science centres which should not be jeopardized by limiting their scope of action to the provision of formal education.

2	*Science centers work better for boys than for girls.*	The effectiveness of science centres is independent of the gender of their visitors - but there is still room to improve inclusiveness and avoid reproducing gender-related stereotypes
3	*Schools can learn more about teaching science from science centers than the other way round*	As far as transversal skills are concerned science centres have a clear advantage in relation to schools, but they have a lot to learn from schools science in pedagogical terms, learning design – and especially in student-centred learning approaches.
4	*Science centers should not promote science careers - that's not their job*	Science centres should promote science-related careers, but not in the same way as career counselling institutions. The focus must be set on the science learning and scientific attitude that are intrinsic to science careers, rather than merely on their job profile or economic attractiveness.
5	*Science centers rarely focus on the relationship between science and industry*	Science-industry collaborations are very dependent on the context of each science centre, where some, by the nature of their stakeholders and trustees, are more likely to invest in this kind of relationship. But, as a matter of general principle science centres should put the connections between science, business and industry at the top of their agendas.
6	*Students acquire skills in science centers which are highly beneficial for their lives after school*	Science centres are particularly effective in the acquisition of observation, curiosity, inquiry, and interdisciplinary and other transversal skills that are key for the development of lifelong learning competences, which, in turn, are essential in adult life.
7	*Most science centers don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society*	Because of their nature as driving forces for knowledge society, science centres are still too traditional in exhibition development, leaving limited scope for creativity and innovation
8	*The soft skills that one aims to achieve are important, but these can also be reached via other (extracurricular) activities like sports, arts appreciation etc.*	Although all extracurricular activities are potentially beneficiary for the development of soft skills, some are more effective than others in relation to some of those skills. Clearly, science centres take the lead in skills that are based on observational, inquiry and critical thinking attitudes.
9	*Focusing on the soft skills in schools will lower the results in test scores by taking time away from tested skills. That's where science centers can play a role*	The role that science centres play in soft skills depends on how society as a whole and school value these skills. If that they are not sufficiently valued in school – which is apparently demonstrated by the fact that they are not assessed in test scores as other skills do – the role of science centres in this regard might also be undervalued.
10	*Visiting a science center has little impact on whether students follow careers in STEM*	The impact of science centres in attracting students to STEM careers decreases as they get older, especially if their contact with science centres is limited to a single

		school visit. A lot more has to be done to invest in project oriented activities, with a longer time span and frequent returns to the science centre, which are proven to be more effective in triggering and retaining students' interest for science-related careers.
11	*Science centers do trigger the attention of children, but do not invest in learning processes with real long term impact*	Most science centre do not include in their mission the development of learning processes with real long term impact – the focus is usually set on connecting people to science – because it is seen as the role of schools. However, due to the specific characteristics of their learning environments, science centres may be better designed than schools to promote the kind of transversal skills that are proven to be highly effective in persistent in people's everyday lives, long after they have left school – they should, therefore, invest more in learning processes that favour the development of these skills.

3.2. Advantages of informal learning in science centres and museums

The analysis of the key patterns emerging from the discussion of the 11 statements in both focus groups has identified the following advantages of science centres and museums:

- Science centres and museums are especially designed as out-of-school learning environments, with an emphasis on developing interest in science, by inducing excitement and motivation to learn.

- Learning in science centres is driven by the learner´s own motivations, as a free-choice process that is more likely to engage visitors in a science learning experience.

- Because of their links to the scientific community science centres provide a direct contact with science practitioners, the process of science and its impacts in society.

- As informal science learning environments science centres provide enhanced opportunities to observe, explore, question and understand phenomena of both the natural and social world.

- Science centres have the advantage of keeping visitors in pace with the most recent developments in science and technology and their applications in every-day life.

- Science centres can be more effective in improving students' curiosity for and attitudes toward science.

- The interdisciplinary nature of many science centre activities provides a better ground for the development of critical thinking, team work, inquiry methods and other transversal skills which are essential for lifelong learning of science.

- Science centres have links with the community as a whole which make them more effective to engage students in a more authentic scientific inquiry, through participation in citizen science, community projects and programmes that address real-world needs.

3.3. Challenges for informal STEM education through science centres and science museums

The discussion of the 11 statements, in both groups, made clear their perception of key challenges that science centres have to address to make informal STEM education more effective. These challenges are:

- The provision of programmes that promote learning experiences with a long standing impact of their learning outcomes.
- To improve the collaboration with formal education in ways that enhance the interplay between transversal and subject matter related skills.
- To introduce assessment methods which are better adapted to informal science learning activities and environments.
- To be more responsive to local community's needs, in ways that stimulate active partnerships with key players in business and industry.
- To address specific individual needs of learners, by recognizing and addressing diversity in the students' learning styles, skills and backgrounds.
- To keep in pace with the fast development of science and technology, and express them both in their exhibitions and activities.
- To bridge the increasing gap between those who produce scientific knowledge and those who are impacted by its applications in everyday life.
- To promote scientific citizenship and engage the public in a rational and critical debate about science and technology.
- To shift the focus of their activity in science communication from the popularization of science to a more active participation of citizens in science.

4. Recommendations

The following recommendations derive from the conclusions, advantages and challenges presented in this report, as well as from the analysis of the participants' written accounts of their views, the discussion of the 11 statements in both focus groups and the video recording of the sessions.

Recommendation 1

Informal science learning activities should be designed through processes involving a more effective collaboration with schools, not only through project oriented programmes that involve repeated visits to the science centre, but also through more effective planning of the visits and their follow-up.

Recommendation 2

Exhibitions, learning activities and educational tools should be developed with the active involvement of key stakeholders, including students, teachers, science education researchers, scientific institutions, universities and education authorities.

Recommendation 3

Informal science learning, as provided by museums and science centres, should be subject to systematic educational research and evaluation, in view of peer-reviewed.

Recommendation 4

To improve the quality of informal science learning, more effective assessment tools and materials should be developed in a collaborative process engaging museum and science centre educators, science education researchers, teachers and science experts.

Recommendation 5

Learning experiences at the museum and science centre should address the diversity of learners, building on their prior experience, knowledge and specific learning needs.

Recommendation 6

Museums and science centres should reinforce their links with their local communities, acting as effective environments for social, economic and cultural development, involving key actors in these areas, particularly in civil society and research organizations, education, policy-making, business and industry, as a backbone strategy to increase the effectiveness and long term impact of the soft skills.

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Carlos Catalao Alves, PhD Education, University of Cambridge, UK; Secondary school teacher until 1990, when he became head of the Multimedia Unit in the National Centre for Training of Trainers, where he got involved in a number of European projects in the area of the training of trainers. He was latter invited as multimedia developer for education and teacher training in Cambridge, United Kingdom. Back in Portugal, he was responsible for the unit of New Technologies for Education, at the Institute for Educational Innovation, Ministry of Education. Latter, in 1996, he joined the founding team of Ciencia Viva as project director. In 2002, he returned to Cambridge for a PhD in science education and communication. Back in Lisbon, in 2005, he became the chief of staff of the councillor for Education and Culture in Lisbon. He is now a member of the board of directors of Ciencia Viva, the Potuguese National Agency for Scientific and Technological Culture.