Flanders
State of
the Art

International report on Catalysing Innovative STEM-competences through informal learning

With focus on informal learning in Science centres and Science museums

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STEM

SCIENCE TECHNOLOGY ENGINEERING MATHS

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Dear Reader

We know from previous social science research that some groups of young people regard science, technology, engineering and mathematics (STEM) as 'not for me' and that there's often a perceived disconnect between the STEM content provided in the classroom and the insight how it can be applied in the "real" world. We also know that experiences outside the classroom -in more informal settings- can be crucial to unlocking people's interests.

When looking at those students who show interest, creativity and motivation for science, technology, engineering and mathematics it appears that they very likely have been triggered by STEM learning experiences outside their school. Learning techniques in such environments seem to focus more on interdisciplinary approaches, on problem solving, groups work, flexibility... and as such, they increase the soft skills that students need for the future workforce. Science Centres and museums should therefore become more significant in overall STEM planning.

The Association of Science and Technology Centers (ASTC) wanted to explore how Science Centres can play a larger role in bridging the gap between the youngsters and their future world of employment and provide them with the skills to become innovators when they get a job. ASTC based itself on studies by the OECD which indicate that countries that achieve well in the PISA ranking (high achievement for science learning in schools) not necessarily have youth being interested in science or being creative with what they learn. However, we do see that young people who have a creative approach towards the PISA-subjects, have been exposed to hands-on activities, to group work etc... things that science centres are better at achieving than (most) regular schools. Similarly, school systems that include hands-on approaches and which place STEM in a lively context seem to be more successful at motivating kids toward science. The results seem to indicate that Science Centre type of activities can seriously contribute to increase students' motivation. ASTC therefore wanted to explore how such activities in different countries relate to what is done in schools and if there is any evidence of impact on motivation of young people at all. Of course, it is obvious that results will differ from country to country and that is why ASTC wanted to explore, in some depth, how Science Centre activities in different countries relate to what is done in the regular class room environments. The outcomes are of extreme importance since motivation and creativity are core to what the industry is expecting from young people in order to become part of the new innovation-based economy. Science Centres could indeed take centre stage to contribute to that larger objective. By means of Focus Groups in several countries ASTC explored the role Science Centres and museums play towards STEM and to indicate to what extent Science Centre type of activities can contribute to increase students' motivation. The focus groups explored how informal learning activities have the potential to make a positive impact on young people's engagement with science, technology, engineering and mathematics.

The preparatory work as well as the overall analysis were funded by the Flemish Department of Education and Training (Belgium). As such, this paper is the result of the collaboration between the ASTC and the Flemish Department of Education (Belgium) with extensive content related input from countries all over the world. EduConsult managed the process.

We are convinced this document will prove to be a useful tool for policy makers, Science Centres, Education and Training providers and learners, in order to improve the nature of STEM activities in Science Centres, to use Science Centres more intensively for strengthening STEM education at school and to make informal learning an exciting reality for all. Informal and formal learning can go hand-in-glove in order to improve the interest in and motivation for STEM studies and careers.

We encourage everyone involved to make solid use of this tool, and to support its dissemination and implementation.

Micheline Scheys

ASTC

The Flemish Department of Education

Definitions of terms used

Exhibit – exhibition: exhibits in the Australian and also the Flemish context refer to the individual experiences and components that make up the larger exhibition. So a large exhibition may have around twenty exhibits within it, for example.

Explainer/ facilitator/ science communicator: These three terms are used to refer to the people who explain the exhibits at the science centre or museum or communicate about them.

Formal learning[1]**:** Formal learning is always organised and structured, and has learning objectives. From the learner's standpoint, it is always intentional: i.e. the learner's explicit objective is to gain knowledge, skills and/or competences. Typical examples are learning that takes place within the initial education and training system or workplace training arranged by the employer. One can also speak about formal education and/or training or, more accurately speaking, education and/or training in a formal setting.

Informal learning[2]**:** Informal learning is never organised, has no set objective in terms of learning outcomes and is never intentional from the learner's standpoint. Often it is referred to as learning by experience or just as experience. The idea is that the simple fact of existing constantly exposes the individual to learning situations, at work, at home or during leisure time for instance. This definition, with a few exceptions (see Werquin, 2007) also meets with a fair degree of consensus.

Mid-way between the first two, **non-formal learning**[3] is the concept on which there is the least consensus, which is not to say that there is consensus on the other two, simply that the wide variety of approaches in this case makes consensus even more difficult. Nevertheless, for the majority of authors, it seems clear that non-formal learning is rather organised and can have learning objectives. The advantage of the intermediate concept lies in the fact that such learning may occur at the initiative of the individual but also happens as a by-product of more organised activities, whether or not the activities themselves have learning objectives. In some countries, the entire sector of adult learning falls under non-formal learning; in others, most adult learning is formal. Non-formal learning therefore gives some flexibility between formal and informal learning, which must be strictly defined to be operational, by being mutually exclusive, and avoid overlap.

Innovation skills[4]: They include basic skills such as reading and writing, academic skills, technical skills, generic skills such as problem solving and "soft" skills such as multicultural openness and leadership. Managerial and entrepreneurial skills are also mentioned, as are creativity and design. People also need the skills that enable them and their workplace to "learn". This can encompass competencies ranging from technical to interaction skills. There is also growing interest in consumer skills for coping with new technologies and contributing new ideas.

Soft skills[5]**:** Soft skills are behavioural competencies which are broadly applicable both in and outside the workplace. They include proficiencies such as communication skills (being able to communicate), conflict resolution and negotiation, personal effectiveness, creative problem solving, strategic thinking, team building, influencing skills, dependability and conscientiousness, to name a few. They are personal attributes that enhance an individual's interactions, social functioning, job performance and career prospects. Example: the "soft" skills required for a doctor, would be empathy, understanding, active listening and a good bedside manner. The "hard" skills necessary for a doctor would include a vast comprehension of illnesses, the ability to interpret test results and symptoms, and a thorough understanding of anatomy and physiology.

[1] *http://www.oecd.org/edu/skills-beyond-school/recognitionofnon-formalandinformallearning-home.htm*
[2] *id*
[3] *id*
[4] *OECD (2011), Skills for Innovation and Research, p. 9-10, http://www.oecd.org/innovation/inno/47164461.pdf*
[5] *Introductory text Walter Staveloz*

List of Abbreviations

AISL: Advancing Informal Science Learning

ASTC: Association of Science Technology Centers

CERN: Conseil Européen pour la Recherche Nucléaire (European Council for Nuclear Research)

CPD: Continuous Professional Development

IBSE: Inquiry Based Science Education

MIM: Museo Interactivo Mirador (Chile)

NGO: Non-governmental organisation

NSF: National Science Foundation

PD: Professional development

PISA: Programme for International Student Assessment

SC: Science Centre

S1: We should let children just enjoy science centres, not turn centres into schools.

S2: Science centres work better for boys than for girls.

S3: Schools can learn more about teaching science from science centres than the other way round.

S4: Science centres should not promote science careers - that's not their job.

S5: Science centres rarely focus on the relationship between science and industry.

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

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

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.

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 centres can play a role.

S10: Visiting a science centre has little impact on whether students follow careers in STEM.

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

STEM: Science Technology Engineering and Maths

STEAM : Science Technology Engineering Arts (All subjects) and Maths

TIMMS: Trends in International Mathematics and Science Study

VET: Vocational Education and Training

Country Codes

AU: Australia

BEnl: Flanders – Belgium Flemish Community

CL: Chile

CO: Colombia

DK: Denmark

IL: Israel

IT: Italy

KR: Republic of South Korea

PT: Portugal

TH: Thailand

ZA: South-Africa


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PART 1: Comparative International Report

Executive Summary

In order to find out whether and how science centres and museums can contribute to catalysing innovation skills for STEM, the ASTC asked its international members to organise focus groups, with discussions based around 11 statements. 11 countries or regions reacted positively (Australia, Chile, Columbia, Denmark, Flanders, Israel, Italy, Korea, Portugal, Thailand and South Africa) and set up focus groups involving teachers, science communicators and representatives from industry. As can be learnt from the definition above innovation skills are encompassing as well soft skills as technical skills. It is very often the focus on the former that is lacking in formal education, hence the importance of finding out how informal learning environments in general and science and technology centres and museums in particular can enhance these innovation skills.

In their national reports some countries added a description of the STEM policy in their country. Interestingly, in all countries where a national action plan for STEM exists, science centres and museums are seen as partners to implement the national STEM strategy.

Although the socio-economic background and the results in PISA and TIMMS of all the countries concerned vary widely and the practices in the countries concerned may differ, it is nevertheless surprising to see that their expectations and views on the role of science centres[6] in acquiring innovation skills for STEM are largely similar.

In all focus groups the participants agreed that science centres can be an effective environment for young people to acquire innovation skills necessary to participate in the 21st century workforce. Regrettably the number of young people reached by the science centres is not as large as participants would like to see. Sometimes this is because science centres are not accessible for all because of the distance to the science centre, sometimes because certain disadvantaged socio-economic groups do not visit science centres with their families. Participants also point out that young children will only acquire innovation skills if science centres collaborate with schools or if they work on a regular basis with young children as acquiring skills is a long-lasting process. Virtually all participants refer to schools as the privileged partners of the science centres.

It was also stressed in all focus groups that children should enjoy the science centre activities because learning can take place in a "safe" environment where failure is allowed – which is more motivating (S1). The participants also stressed that the wonder-like environment of the science centre and the possibilities for science centres to offer more sophisticated equipment than schools trigger the attention of the children (S11). However they also pointed out that children acquire skills through participating in activities rather than by looking at exhibits.

Opinions varied on whether schools can learn more from science centres than the other way round (S3). Only in Belgium and Australia participants thought that schools and science centres have as much to learn from each other and that there should be no competition as to who has to learn from whom. On the other hand participants in Chile, Colombia, Korea, Portugal and South Africa thought that schools have a lot to learn from science centres as far as didactical approaches and especially Inquiry-based Science Education (IBSE) are concerned.

Although virtually all participants believe that students **can** acquire skills in science centres which are highly beneficial for their lives after school (S6), the participants in Flanders, Chile, Colombia, Denmark and Israel stress that this is only the case if children visit the centre on a regular basis or if there is a link with what is taught at school. Especially in Flanders and Denmark the remark is made that science centres plant the seeds but that these must be developed at school or through regular visits to the science centre or other activities.

It is not surprising that in all the focus groups the participants agreed that the soft skills aimed for are important, but that these can also be reached via other (extracurricular) activities like sports, arts appreciation etc. (S8). In several countries participants pointed out that young people acquire some skills more easily while working on a technological project and others while practising sports but that skills acquired in one context can be strengthened when implemented in another context.

Considerable differences between countries appeared on the statement that focusing on soft skills in schools would lower the results in test scores by taking time away from tested skills (S 9). In Australia, Flanders, Chile, Denmark, Israel and South Africa especially corporate participants feel that soft skills are as important as hard skills. Moreover in most of these countries soft skills are also assessed at school. In contrast the participants in Korea, Portugal and Thailand, where education is still predominantly concerned with knowledge acquisition and exam results, think that Science centres can play a role and fill up the gap that is left by schools.

Regarding the science centres' investment in long-term learning processes all participants have rather nuanced opinions (S11). They feel that a distinction should be made

[6] *The term Science centre is used to refer to Science and technology centres and museums in order to enhance the readability of the text.*

between different types of science centres and that traditional science centres cannot invest directly in long-term learning processes. However many of them do this anyway through professional development (PD) activities for teachers or through the development of learning materials. It should also be mentioned that in some of the countries concerned, "science clubs" or "academies" exist and that these are more concerned with investing in long-term processes.

The focus group discussions also revealed that science centres will have to implement programmatic changes to face the challenges of the 21st century. Instead of focusing on exhibits, science centres will have to focus more on activities that trigger creativity and innovation and contribute to the knowledge society. Although in several countries participants think that recently science centres have been doing a lot to trigger creativity and innovation, many felt that more should still be done (S7). Especially in Colombia, Denmark and Portugal participants believe that more should be done in this area. In several countries examples were given of science centres or science clubs that work with young people on a regular basis thus having a much bigger impact on the participants. In the future more attention should therefore be paid to science clubs or small or mobile science centres that make them accessible to more children.

Science centres should also focus more on girls (S2). All participants agreed that Science centres work as well for girls as for boys but many activities very often seem to attract more the boys' interests. Participants point out that the gender issue is a societal issue but at the same time they note that in adolescence interests of girls and boys grow apart and that exhibits and activities in science centres are more directed towards boys. They also note that there are few activities for young people over 15 (where difference between interests between boys and girls is growing wider).

In most countries participants disagreed with the statement that science centres rarely focus on the link between science and industry (S5), although this is usually more implicit than explicit. Virtually all agree that focusing on this link should be part of the future agenda of the science centres taking into account the ethical dimension and the corporate social responsibility of the companies.

In all countries except Chile and Israel the participants more or less agree with the statement that science centres should not promote science careers (S4). In Chile and Israel participants totally disagree. with the statement. However, all participants agree that science centres should inform students about science careers through role models. They should especially show what one can do with science and how scientists or engineers can face the challenges of our future society.

Only the Israeli participants totally disagree with the statement that visiting a science centre has little impact on whether young people pursue a science career (S10). In most countries participants pointed out that visiting a science centre can have an impact on the choice for a science career but that there are also other factors like parents, the school, the media that often are more important contributing factors. However, it is important for Science centres to give a positive, though realistic view of science careers.

Reaching out to new target audiences should also be part of the new agenda of science centres: science centres should reach out to teachers, students in teacher education, parents and children in remote areas or from less privileged families. Especially the latter group seems to benefit a lot if they can visit a science centre or science club on a regular basis.

Although there were no statements on the systematic professional development of science centre practitioners and the management, several focus groups touched upon this item. They pointed out that science centres can organise professional development courses for teachers especially as far as new teaching approaches and IBSE are concerned. They can thus have an indirect impact on the long-term learning processes of children (S11). In several groups the need for professional development of science communicators was also mentioned. The only country where this is already taking place on a systematic basis is Australia. A number of participants stressed that if the science communicators lack the knowledge and skills to communicate with children of different ages the effect of the visit could be negative. It is therefore of great importance to provide systematic professional development courses for them.

The focus groups clearly showed that although the current situation in the countries is sometimes quite different, the expectations of the participants are largely similar. They expect science centres to enhance the collaboration with schools, address new audiences, be accessible to all young people, provide professional development for teachers and science communicators. They also want the science and technology centres to provide even more activities that trigger creativity and innovation, focus more on long-term activities, take into account the interests of the visitors, show them the purpose of science through examples in everyday life and role models and, most of all, let children enjoy Science in an unusual and often wonder-like environment so that their motivation for Science is enhanced.

1. Introduction

In order to increase the ability of science centres to facilitate awareness and development of 21st century innovation skills in youth, the Association of Science-Technology Centers (ASTC) in collaboration with the Flemish Ministry of Education has set up a comparative study about the role of science and technology centres (informal science education institutions) in preparing the youth for innovation in the economy. The object of this study was "Catalyzing STEM Innovations Skills in Informal Learning". **In the context of the present study only informal /non-formal learning in science centres and science museums is focused on.**

The starting point of this study was the observation that children in countries with a high PISA-ranking on mathematics and science literacy (like Flanders and Finland) are not necessarily interested in STEM and motivated to pursue further studies in this area. So the question arises of how the strong results in STEM abilities during formal education could be linked to an increased motivation for these topics at later areas. In different countries, it has been observed that students who are interested in and motivated for STEM have often been in contact with STEM in out-of-school environments, where learning methodologies are more based on interdisciplinarity, problem solving, teamwork and flexibility - so-called "soft skills" that are in demand in business and industry. As science and technology centres are by definition out-of-school environments the ASTC (and its participating members) and the Flemish Ministry of Education wanted to find out what role museums and science centres could play in supporting a STEM-policy and the acquisition of STEM competences.

For the comparative study focus groups were held in 11 countries in Europe, Africa, Asia, Australia, the Middle-East and Latin America in which three groups of stakeholders were represented: teachers, science communicators in science or technology centres and representatives from industry. In this comparative report the results of the 11 focus groups are compared. Recommendations are given to science and technology centres to become more effective in helping young people to acquire innovation skills necessary to participate in the 21st century society. In addition, professional development strategies are suggested for science centre practitioners to support STEM-strategies.

2. Outcomes of the focus groups

2.1. Methodology

In order to explore how the different types of science centre activities can contribute to increasing students' motivation, ASTC invited several countries to organize two focus groups. All groups were asked to follow the same discussion mode in which a series of 11 statements were submitted to the focus groups in the same order. All groups needed to consist of representatives of the three major stakeholders: science teachers; science communicator professionals from science centres and people from corporations. A protocol established by a group of experts and that had to be the same in every participating country was to be followed[7].

A scientific committee was established to steer and monitor the activities. It consisted of the following members:

- *Walter Staveloz*, Director, International Relations, Association of Science-Technology Centers (ASTC), Washington DC,
- *Prof. Justin Dillon*, Head, Science and Technology Education Group (STEG), King's College London. Professor of Science and Environmental Education & Head Graduate School of Education, University of Bristol,
- *Stephan Vincent-Lancrin*, Senior Analyst, Centre for Educational Research and Innovation, OECD (Paris)
- *Dr. Carmen Sánchez*, Jefa de Comunicación Institucional y Relaciones Públicas, Universidad Nacional Autónoma de México (UNAM), FD Mexico.
- *Elaine Reynoso*, Coordination Diplomado en Divulgación de la Ciencia,UNAM, FD Mexico
- *Carlos Alves PhD*, Adjunct Assistant Professor of Management and HR Management at Nova School of Business and Economics, part of the founding team of Ciência Viva, the Portuguese National Agency for Scientific and Technological Culture, Portugal (Cambridge UK)
- *Rosalia Vargas*, President of Ciência Viva – Pavilion of Knowledge in Lisbon, Portugal Portugalr Beverley A. Damonse, Group Executive: Science Engagement and Corporate

[7] *See full protocol as annex 1*

Relations of the National Research Foundation (NRF),

- *Tony Lelliott*, Associate Professor , Science and Technology Education, Witwatersrand University
- *Michael Peter*, CEO of Sci-Bono Discovery Centre
- *Derks, Anton*, Scientific Advisor, Flemish Department of Education, Brussels, Belgium
- *Dunon, Rita*, Policy Advisor at the Flemish Department of Education, Brussels Belgium

The head of the scientific committee as well as other members of the scientific committee and the authors of several national reports participated in a number of telephone and videoconferences to approve the table of contents of the national and international report.

Eleven countries participated in the project. The participants were (countries and corresponding science centre): Flanders (Technopolis) , Denmark (Experimentarium), Italy (Leonardo Da Vinci), Portugal (Pavilion of Knowledge), South Africa (Sci-Bono), Chili (MIM), Australia (ANU-Questacon), Korea (Everyday science class), Thailand (NSM); Colombia (Maloka) and Israel (Weizmann Institute of Science).

In most countries two or three focus groups were held. These focus groups debated 11 statements that were proposed by the scientific committee and would be the basis for the international study: "Catalyzing STEM Innovation Skills in Informal Learning".

The statements (see next paragraph) focus on the role of Science Centres (SC) and museums in catalysing innovation skills for STEM. The participants to the focus groups were a mix of science communicators, teachers and representatives from business and industry. The statements were not sent in advance to the participants and the focus groups lasted 90 minutes. A facilitator was appointed to lead the focus group in the right direction and a rapporteur followed the debate that was also recorded.

The Flemish Department of Education was invited to organize a try-out focus group to find out whether the 11 statements were clear and whether the protocol proposed - 90 minutes for a focus group, statements not sent in advance etc. – were feasible. After the try-out an online questionnaire was sent to all participants. It turned out that most participants wanted clear definitions of certain terms used (what is meant by a science centre, by soft skills etc.) and some clarifications on some of the statements. Based on the try-out and the survey, a report[8] was drafted and recommendations were sent to all participating countries as well as a template to be used for the national reports. Because of different academic calendars in the countries concerned some countries had already held their focus groups before the template and the recommendations were sent out. Some of them adjusted the original country report taking into account the template. In one country (Italy) not all statements were discussed and some statements were changed.

The report of the Flemish focus-groups as well as the synthesis report of the national reports of all the countries concerned are financed by the Flemish Ministry of Education and Training.

2.2. The 11 statements

As mentioned before, the statements were not sent to the participants in advance. The participants were asked whether they agreed or disagreed with the statements and why.

The statements discussed were the following:

1. We should let children just enjoy science centres, not turn centres into schools.

2. Science centres work better for boys than for girls.

3. Schools can learn more about teaching science from science centres than the other way round.

4. Science centres should not promote science careers - that's not their job.

5. Science centres rarely focus on the relationship between science and industry.

6. Students acquire skills in science centres which are highly beneficial for their lives after school.

7. Most science centres don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society.

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.

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 centres can play a role.

10. Visiting a science centre has little impact on whether students follow careers in STEM.

8 *See full report as Part II of this International report*

11. Science centres do trigger the attention of children, but do not invest in learning processes with real long term impact.

In order to see whether there were considerable differences in the reactions to the statements in the countries concerned, a comparative table was made. + = majority agrees, - = majority disagrees, ± = divided opinions or participants agree more or less, ? = discussion not focused on the statement.

2.3. Summary of the discussions per statement

1. We should let children just enjoy science centres, not turn centres into schools.

Although in BEnl, DK, CL, CO, IL PT, TH and ZA most of the participants to the focus-groups agree with this statement they also point out that enjoying does not exclude learning. In Australia participants wanted a 'middle ground' to this option and were in large agreement that science centres were different to schools, mainly because of the element of 'fun'. Although participants also acknowledged that school should also be enjoyed, and enjoyable, both settings have different purposes and functions. Some participants stressed that although science centres should be enjoyed they're not only fun. In this respect one of the participants in Chile pointed out that enjoyment should not be associated with fun. For example, to enjoy something is the most rewarding experience; when you fail once and again and finally hit the target one is enjoying it, not having fun. In Flanders, several participants stated that on the one hand children should enjoy schools as well and on the other hand science and therefore science centres are more than just fun. However, the majority thought that children should enjoy being in a wonder-like environment. Several participants also thought that in order to be effective the visit should be prepared and followed-up especially when carried out in a school context but that while in the SC children should enjoy themselves.

The overall results are displayed in the table below.

Statement	AU	BEnl	CL	CO	DK	IL	IT	KR	PT	TH	ZA
1	±	+	+	+	+	+		±	+	+	+
2	-	-	-	-	-	-		-	-	-	±
3	-	-	+	+	±	±		+	+	±	+
4	±	±	-	±	±	-		±	±	±	±
5	-	±	-	+	±	-	-	-	+	-	-
6	+	±	±	±	±	±	+	+	+	±	+
7	±	-	-	+	+	-		-	+	-	±
8	+	+	+	+	?	+	+	?	+	+	+
9	-	-	-	±	-	-	±	+	+	+	-
10	+	+	±	±	+	-		±	±	+	±
11	±	±	±	±	±	-	±	±	±	±	±

Figure 1: comparative table

In Denmark learning is also an important element at SCs, as well as in schools, but it is important that the way of learning in SCs is playful and free - not traditional black-board teaching. The free environment can even enhance learning. Science Centres should not be seen as amusement parks. Also in Colombia the participants were convinced that an open and playful environment facilitates scientific learning. In Thailand all participants think that when children are allowed to choose their own learning methods and topics they will be more eager and enthusiastic to learn. The participants in Israel also think that enjoyment in Science Centres must be maintained as it brings motivation to the students for studying science. The Israeli participants also pointed out that collaboration with Science Centres encourages schools to teach science in many ways so that children will also enjoy structured learning. The idea of complementarity is a common concern across all Portuguese stakeholders: both formal and informal approaches are seen as particular traits of science centres. However, especially 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

The South African context is a special case. Science centres should not take on the role of schools. However, the varying quality of school education in South Africa means that certain aspects of schooling (particularly practical work) can be taken on by SCs. The lack of resources within many schools was noted as a concern. Where resources (in their fullest sense) are absent, then SC do take on the school role. The corporation representatives and SC professionals strongly felt that learning and enjoyment should go together in science centres.

In South Korea the participants mainly stress the different way of learning (hands on and project learning) in Science centres, viewing it as something to be enjoyed, not as an extension of school education.

Most participant to the focus groups think that schools and science centres should be complementary and that what is being offered in science centres should be additional to what is done in schools. Schools can learn from science centres especially as far as didactical approaches are concerned and science centres can learn from schools about their target audiences. In several countries it was pointed out that science centres have more resources than schools and that they have the possibility to exhibit and demonstrate phenomena the pupils have learned about at school. In Colombia two different positions were put forward about the SC's relationship with school, one more focused on the understanding of science centres as exploration experiences that mainly inspire and motivate, versus a point of view that emphasizes the necessity of a thoughtful connection between field trips and classroom activities.

This statement was not discussed in Italy.

2. Science centres work better for boys than for girls.

Virtually all participants disagree with this statement. Although the participants in South Africa did not entirely disagree there was consensus about the fact that this was a societal issue. This was expressed particularly strongly by the corporation and science centre representatives, who also suggested that SCs need to militate against this societal issue by encouraging more participation by girls. SC exhibits and practices therefore need to encourage participation by both genders. The examples of robotics and computers were given that engage boys more than girls. Also in Flanders the remark was made that more boys probably visit SCs because the exhibits and themes are more aimed at boys than at girls especially when teenagers are concerned. However, especially female participants thought it was an outdated statement and the teachers stated that when they visited a SC they never noticed any difference in interest and motivation especially in younger children. Nevertheless they admitted that still more boys than girls choose (hard) STEM studies but they pointed out that this wasprobably due to the expectations of society. The Israeli participants also stressed that Science Centres should be a-gender and that no difference is noticed in younger children. For teenagers Science Centres have more items and topics of interest to boys than girls. The participants in Colombia also mentioned that boys and girls have motivations that may be different but not "better or worse". Boys are very good to work with technology but the girls' ability to communicate it, is excellent although the biggest difference is perceived in terms of age when one observes that interests change. In Denmark SCs are not perceived as being better for boys than for girls. The discussion about this issue was even not perceived as relevant to the participants. The participants thought it is more relevant that SCs can make weaker students understand science. Nevertheless the participants admitted that industry lacks more science-interested girls and that there may be differences in the time boys and girls spend at an exhibition. Also in South Korea this statement was seen as a sexist generalization. While there may be certain areas or subjects that students of different genders prefer, the difference comes from their personal disposition, not their gender. It is also true that there are more boys than girls at the Science Centre but with primary school students, the ratio is more affected by their parents than by their own decisions. While the science museum program initially targeted boys, it now helps more girls to have better access to science, and take a more active part in the learning experiences and there is a 50/50% ratio of boys and girls. In Chile some participants regarded this statement as misogynist. They also pointed out that every child is an individual, regardless of

his or her gender. In fact, there's a lack of strengthening science among girls. They also referred to the cultural context and the tenet (a belief or idea that is very important to a group) about science and women. It has been established beforehand that women are terrible for science and math but while travelling science museums and working in industry the participants have seen more girls interested in science compared to boys. Also in Australia this statement was disagreed with by all participants. The overarching consensus was that boys and girls may approach tasks or programs differently, and this could be due to the different developmental stages and cognitive development. There may be certain elements of a visit that appeal more to one gender than another however there is no difference in overall engagement between the genders. Also here it was pointed out that a science centre should appeal equally because there is such variety of exhibits, styles and types. As in the other countries the participants in Colombia pointed out that there is no difference in the dynamics that occur in the centre according to gender but they also mentioned that the interest that children have in science centres changes through adolescence. In Thailand the participants referred to studies that had shown that both male and female learn at similar levels but in different ways. In Portugal the majority also disagrees with the statement but especially the industry-group thinks that the focus on technology and engineering in SCs renders them more efficient for boys than for girls.

In several countries the remark was made that Science museums and Centres should re-consider the exhibition design and the exhibits for teenagers so that they would be as appealing for boys as for girls. Moreover the explainers/guides/communicators also have a significant role-model part in closing the gender gap.

This statement was not discussed in Italy.

3. Schools can learn more about teaching science from science centres than the other way round.

Most participants in Flanders, Israel and Australia disagree with this statement. Participants think that there must be interaction and feedback between schools and science centres and that the starting point must be that they can learn from each other. Both are compatible and complementary. They also added that learning is not about being better than but about interaction and learning from each other. Science centres and schools should not act as competitors but should work together in order to enhance STEM education. Some participants in Flanders pointed out that although the collaboration between science centres and schools already exists it could still be enhanced. Reference was made to an exhibit that a teacher had seen at Technopolis and that she wanted to recreate in her school. She received all the information asked for but also gave feedback on how the experiment could be recreated with cheaper materials. This kind of interaction should be generalised. Science centres could also lend materials or expensive equipment to schools (e.g. a catalyst). In Australia all participants noted that there was a mutual exchange of skills and ideas between science centre staff and teachers. Typical comments included noting that there was integration between the two sectors. The formal education sector, and the educators who work within it, can gain a lot from seeing how science centres engage children in science, which can translate to a change in their teaching practice. Science centre staff also saw the teachers who attended programs assist each other in peer to peer learning. They highlighted the role that teachers can play in science centre staff development, especially as regards knowing the most effective ways to communicate with children. Although in Israel most participants disagreed with the statement and thought that there is mutual learning between the schools and the centres as each has its own strengths, the Science Centre representatives thought they had nothing to learn from schools.

The majority of the participants in Denmark more or less agreed with the statement because SCs can offer specialized professional scientific knowledge, from which both students and teachers can learn. Course activities by SC teachers can give schoolteachers a common language and create enthusiasm for science subjects. Nevertheless they also pointed out that it's about mutual collaboration and dialogue between schools and SCs. By creating awareness of the differences between schools and SCs, experiences can be brought forward about what each can contribute. Moreover schools make the most of visits to SCs, they prepare it and reflect about it afterwards (a before, during and after the visit). Although there is no unanimity on the position in Colombia, participants in focus groups emphasized the increased capacity that feature science centres for innovation in teaching methods, so most recognized a greater influence of science centres in schools than the other way round.

In Chile, Korea, Colombia, Portugal, Thailand and South Africa most participants agree that schools can learn more from the science centres rather than the other way round. In Chile there are several reasons for this: the structure of the classrooms, the lack of resources and most of all the lack of preparation of the teachers to new didactical approaches. Despite recognizing that

initially science centres made use of pedagogical and scientific information produced within formal education, today science centres can be a source of information and innovation for schools. In Portugal the participants think that schools can especially learn from Science Centres as far as Inquiry Based Science Education is concerned. Also in Thailand most participants agree that schools can learn more from Science Centres than Science Centres from schools.

Nevertheless several participants think schools and science museums should work together and can learn from each other. Many schools focus on the theory either because of time, money, number of students, lack of classrooms, lack of labs etc. The fact of having a science museum or centre is a great support for the work teachers do inside the classroom. Although most participants agree with the statement, some nevertheless point out that the museum can also learn from the schools, from their needs. So this way the museum can work and impact regarding the real needs of the context and the real needs that the schools have. They think that the part of the question that establishes "can learn more" is the complex part. Schools and science centres can both learn from each other because they are complementary. Maybe what the participants were trying to say is that schools use methods that haven't evolved as fast as one would like considering our decade and our constantly changing society. In Thailand some participants think that Science Centres should develop more content consistent to the school curriculum.

Also in Korea most participants agree with the statement. While the recent revisions to the science curriculum have added many of the science experiments that have been conducted in the "Everyday science class" over the past decade, most of these experiments are not actually being carried out at schools due to safety issues, the focus on the university entrance examination and, in some cases, negligence on the part of the school or teachers. One of the participants also pointed out that when at a local high school, the "Everyday science class" was held during regular school hours for the special-needs class for a semester this had a very positive impact on the students.

All the participants in South Africa agreed with this statement. The corporation representatives noted that SCs have more resources than most schools in South Africa, and that the role of the SC is to 'ignite passion' for science, which schools need to learn to do better. The SC representatives noted the need for dialogue between SCs and schools; SCs have a 'teacher inspiring' role, but it should be in relation to the realities of schools. For example, the improvisation of equipment by SC staff can encourage teachers to do likewise.

This statement was not discussed in Italy.

4. Science centres should not promote science careers - that's not their job

All the Israeli participants objected to this statement. They stated that the central role of Science Centres is to encourage curiosity, interest and exploration in science, encourage success by role modelling. This results in promoting and encouraging scientific careers. A suggestion was even made that encouraging scientific careers should be part of the SC agenda.

However on this item the participants in most focus groups (AU, BEnl, CO, DK, KR, PT, TH, ZA) had slightly divided opinions. In South Africa and Colombia the teacher representatives disagreed with the statement; they consider that the role of SCs is to assist in promoting science careers. School students are generally unaware of the varied careers available, and SCs can address this. In contrast, the corporation representatives suggested that promote is too strong a word, but that SCs can provide guidance on the range of opportunities available; they should facilitate awareness and then children can decide for themselves. The SC representatives agreed that children are not exposed to the wide range of careers, and SCs can help to expand their horizons. In Colombia the SC representatives thought they had not enough time to promote science careers except in science clubs.

In Flanders most teachers considered that "promoting" science careers is not the job of the science centres and that "promote" is definitely too strong a word. On the other hand all corporate participants stated that on the contrary it is the job of science centres to promote science careers. However, although some teachers dislike the word "promote[9]" - one even said that it might have the opposite effect, because children don't like to be pushed - most of them think that science centres should inform visitors about a wide range of studies and careers in science and technology. Not only purely scientific careers should be focused upon but the broad spectrum of scientific and technical or technological careers. Students (but also primary school pupils) should know which careers and jobs are possible with STEM. They must realise that science and technology is not only for nerds. When asked how science and technology centres can promote STEM careers the Flemish industry representatives pointed out that they should mainly inspire young people by showing examples of how science and technology can be used and focus on the purpose.

Similar ideas are held in Portugal where virtually all the participants discard the idea of promoting science careers but where 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 specific job profile. However, the Portuguese participants

[9] *In Dutch the word is associated to pushing someone to do something or advertising a product.*

pointed out that science centres should not work as career counselling services. 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. In Australia all participants agreed that science centres should be showcasing opportunities and potential pathways for interested school children. Some argued that schools should be doing much the same thing. Participants felt that there needed to be a balance and that raising awareness of opportunities is a good thing, so long as it was in a more implicit rather than explicit 'you should do this' manner. While it was valuable for students to hear about scientists and specialists, this should not come at the expense of leaving science open as an option for everyone. Also here it was stressed that the whole spectrum of science jobs should be covered and opportunities should be given for students to ask questions of scientists.

Whereas in Thailand the first focus group agreed with the statement but pointed out that by motivating young people for science, science centres could also foster science careers. The second focus group even more explicitly thought that science museums and centres do have impact on the decision in choosing science careers by creating inspiration.

In Korea children initially learn to develop their skills and to respond to problems at the science centre. In the long term, this will help them gain a scientific reasoning and perhaps choose a career in science. There are also children who naturally develop an interest in science as a career after meeting the scientists. Extracurricular science education offers an opportunity for students to find out for themselves if a STEM career is suitable for them or not and it helps broaden the range of career choices. Science centres provide an opportunity for students to find out what they like and what they are good at. They can suggest career options in science and in engineering. After all, the choice is up to the students, and there is no harm in introducing them to the options.

Also in Denmark the participants more or less disagreed with the statement. It was pointed out that to promote scientific career paths is not the SC core mission, but it's a really nice side effect and if it happens it' s great (representative from industry). The teachers noted further, that there are many things, which influence the career children choose and hereby it is very difficult to assess, whether the SC was the place, which made the difference. They also noted that it is important that the SC does not promote a scientific career over another - Explainers[10] who are engaged in a scientific career, can serve as role models. The participants pointed out that one should take advantage of the vibrant scientists who are in a science centre.

Though in Chile most participants agreed with the statement, a few disagreed. Those who agree with the statement think is not the task of the museum or the science centre, even if is interactive to promote science careers. The objective is to show, to create interest about science and if from there arise professional callings, it is something that just happens. The science centre should try to make science popular, close to people. It should be a contribution to the culture of a place and not to the marketing of careers. Some participants even think that if science centres try to promote science careers through SCs, some people wouldn't come. However, some participants pointed out that science centres and museums do that unconsciously all the time and maybe indirectly different vocations are stimulated. In science centres all the exhibitions are related to science, so obviously they will stimulate science careers. But the objective of the science museum where the focus group was held has never been to promote intentionally science careers; they have never designed an exhibition having that in mind, because they are a museum open to all different kinds of people.

This statement was not discussed in Italy.

5. Science centres rarely focus on the relationship between science and industry

Only in Colombia and Portugal most teachers, as well as representatives of science centres agreed with the statement. The Colombian participants pointed out that there are no strong bridges between industry and science centres. However, the participants thought that this kind of relationship has great potential for the development of other forms of non-formal education. In Portugal 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. Although there are some exceptions the Portuguese participants unanimously expressed that there is an 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.

Just as for the previous statement the opinions on this statement were divided in Flanders but also in Denmark. Whereas in Flanders most participant teachers agreed with this statement, some teachers thought it depends on the kind of science centre. Most corporate representatives were convinced that most sciences centres do focus on the relationship with industry and that those who don't, should focus on the relationship with industry in the future. Although most teachers considered that science centres rarely focus on the relationship with industry, there was a general consensus among all par-

[10] *People at the Experimentarium who are at the exhibition and can explain about science.*

ticipants that science (and technology) centres should do so. They clearly pointed out that the relationship between science centres and industry should not focus on sponsorship but that SCs should focus on what graduates can do in industry when they have finished scientific or technical studies. This is especially important for older students. Some point out that this is already the case in certain centres. In Technopolis there is an exhibition room (Xplora)[10], co-financed by industrial sectors, where children can take up several roles, jobs, functions in industry and see whether they like it through a number of interactive exhibits around jobs that are innovative or capture their imagination. According to the participants science centres should inform and motivate the visitors. They refer to the previous statement where they also recommended informing the visitors on a wide range of jobs in industry. A few participants pointed out that children should mainly be triggered and that it could be the role of the science centre to inform the parents.

In Denmark most participants considered that SCs do focus on this relationship, but it is not clear to the pupils. To make students and pupils aware of the relationship, a representative from the industry, suggested the possibility to process the information regarding industry after the visit e.g. by letting the students describe the link with industry. Several participants considered that rather than focusing on the link with industry, science centres focus on societal issues or challenges that Denmark faces such as the lack of resources. Some participants even thought that explicitly emphasizing the link between SCs and industry is not attractive to visitors. However they also suggested to make experiments that are sufficiently entertaining and instructive focusing on industrial products. They also pointed out that it is really hard to get sponsors in the companies in Denmark, even if you could document it. The participants concluded by saying that they want a clearer trinity between industry, SCs and schools. This could generate more interest and motivation in relation to science in schools.

The discussion of this statement in South Africa was very brief. The consensus was that they disagree with the statement, with the SC representatives stating that SCs in South Africa do relate science to industry and the corporation representatives noting that SCs do try. The teacher representatives did not have a strong opinion, and wanted to hear from the other two groups.

Also in Australia, Chili, Thailand and Israel the participants disagreed with this statement. The Australian SC representatives both identified immediate industry links in their science centre – an entire campus dedicated to it as well as a show which had been commissioned by a local organisation. Also the teachers referred to science fairs and school science competitions being funded by industry, thus making science and what you can do with it a tangible thing. The application of the science to the industry was a recurring theme in the discussions with the SC representatives believing that the application of the science is what is most commonly shown in science centres, rather than industry specific exhibits and exhibitions.

In Thailand and Israel the majority of the participants think Science Centres make efforts to focus on industry. However the Thai representatives think that the science museums and centres should produce even more exhibitions in inspiring children's interest in invention and technology. The Israeli representatives point out that Science Centres focus especially on high-tech, and less on traditional industries. The collaboration between Industry and Science Centres results from Industry funding some knowledge centres or their programmes,

The participants in Chili thought that SCs do actually make the link and it is even built in. They pointed out that it is virtually impossible to talk about science without talking about industry. The demonized industry is the practical way in which these science contents become true. In most interactive museums around the world there is always something about industry. The teachers pointed out that this connection is actually present in the study programs in schools and it helps kids to understand the relation between both. Although one participant thought that the Museo Interactivo Mirador (MIM) was an exception most participants thought that there was always a link with industry but not always that visible. The participants also discussed the ethical dimension of the link between a SC or museum and industry especially with kids. They all agreed that science has a direct relationship with industry, but some thought it is a very complicated relationship in terms of conflict of interests. They gave the example of the mining development of copper in Chile and the huge environmental impact behind it. One person thought that SCs had manipulated themselves in terms of industries' promotion. There was also a discussion about the distinction between industry and brands. Most participants agreed that the SC or museum should decide on the content of exhibitions and not the industry even if they were sponsoring it. However, it is possible to use the logo of the sponsoring company.

Also in Korea the participants disagreed with the statement. They even thought that it is the opposite in Korea. There are many cases in which scientific theories can be studied by looking at the real-life examples. They also pointed out that in the "Everyday Science Class" theoretical and practical science education is brought together.

In Italy the participants disagreed as far as the Leonardo da Vinci museum was concerned. The occasions on which the Leonardo da Vinci Museum has put schools in contact with companies have been very special and appreciated by students and teachers. Specific moments that were valued at the Milan museum included: activities where

[10] http://www.technopolis.be/nl/fiche/zones-6-hoofdzones/xplora/

students met researchers at the Museum; having teachers discover the possibility of visiting firms or labs with their classes; putting teachers in contact with experts that would then give talks in schools. In fact it was not discussed whether other science museums focused on the link with industry.

6. Students acquire skills in science centres which are highly beneficial for their lives after school.

In Australia, Korea, Italy, Portugal, Thailand and South Africa the participants agreed with this statement.

The Australian participants mentioned extensively the ability of science centres to foster curiosity, lifelong learning and questioning skills. They stressed that this applies to museums and other institutions as well as science centres. They enhance a fostering for lifelong learning or for curiosity to engage with the world, to not just shut down opportunities and possible learning experiences when one has left formal education. The participants also believed that science centres provide an environment that allows people to develop the confidence to try things and be wrong.

In South Africa there was general agreement that students do acquire such skills in SCs, particularly as a result of extended periods spent there rather than one-off visits. However, such programs only cater for relatively small numbers of students, compared with the total numbers visiting the SC once-off. This is also mentioned by the Thai participants who feel that children will acquire these skills by participating in activities rather than by visiting exhibitions. Moreover these activities should last at least 2-3 days for children to acquire these skills. The Portuguese participants also point out that the impact of these skills is very much dependent on the frequency of the exposure

The Italian participants also agreed with the statement. Even if the experience of a Museum for a student is usually brief, they believe in the "butterfly effect", where even a small change might lead to great changes in lives and personalities. Especially meeting with researchers and professionals really helps students catch a glimpse of the future world. The added value of the Museum methodology and environment is that it makes students feel protagonists, really in charge of their own work and learning experience. Museums are places where you can get in touch with "the real thing" and the "real world".

As the "Everyday Science Classes" in Korea are organised on a regular basis children learn a wide range of skills they need for real life. School textbooks show how to change batteries or connect plugs, but most children have never done any of those things. However, the Everyday Science class helps children to actually learn and apply these useful everyday skills. In particular, less fortunate children build self-esteem, as they achieve success in experiments, work as a team, learn to be considerate of others in group activities, and communicate with and form a friendly relationship with their teachers after class.

In Flanders, Colombia and Chile participants partly agreed that students acquire skills in science centres that are highly beneficial for life. Especially in the first two Flemish focus groups participants stressed the fact that a visit to a science centre is only one step in the process of acquiring competences. Most participants concluded by saying that children can acquire skills for life after school in a science centre but that it depends on the kind of science centre whether and what skills are acquired. If the activities take place on a regular basis then children will acquire skills. Otherwise these skills will have to be further developed at school or in another context. Some participants stated that if the STEM academies or other science clubs are considered it is obvious that students can acquire the soft skills that they need for life after school.

In Chile participants found it difficult to agree or disagree with the statement. On the one hand some participants thought that museums and science centres give you an experience, can surprise you and get your attention, showing new worlds, etc. but soft skills development is training. They pointed out that especially when the visit to the museum is a one off activity, then it will not contribute to soft skills development. But if children go to different science centres, and it is something that he/she continuously does, there can be a soft skill development. On the other hand some remarked that there are different levels of soft skill development. Although it is true that you will not develop a skill coming just one time to a science centre there is a contribution to start the development process, making the kids wonder, etc. They also stated that if schools came to science centres or museums more regularly and made use of the labs then SCs could really contribute to the development of soft skills. They hoped this would be possible in the future. In Colombia teachers observed that despite the short time students stay at science centres, they learn not only about scientific concepts, but also other ways of relating and thinking about the environment. Representatives of science centres were more sceptical about the long-term incidence of sporadic visits by most people visiting science centres. However they nuanced this observation noting that they don´t know studies to support or refute the initial statement.

The Israeli participants couldn't come to a consensus as half of them agreed and half disagreed. The latter pointing to short-term activities, like a one-time short visit, where it is not possible to acquire skills.

In Denmark the participants to the focus groups rather

disagreed with the statement. Several representatives from both focus groups did not describe SCs as making highly beneficial impacts on life after school, but they pointed out that SCs influence, inspire and produce seeds. Some participants wondered whether SCs ever would be able to create the experience of long-term science skills, if these are not processed after a visit.

7. Most science centres don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society

In BEnl, CL, IL, TH, and KR the participants to the focus-groups generally disagree with the statement as they think that science centres do a lot in the way of promoting creativity. In Flanders examples are given of exhibits in science centres that enhance creativity such as causing chain reactions with different materials. The participants stress that especially over the last 10 years a lot has been done to promote creativity and innovation. However more could still be done especially as far as contributing to a knowledge society is concerned. The Thai participants (especially representatives from SCs) point out that that they do have activities which let children invent their work and that this stimulates creativity and innovation. In Chile some participants thought that this statement is too ambitious and that it is difficult to define the word "enough". They also pointed out that some SCs do a lot to enhance creativity and innovation but that not all do. In Korea most participants strongly disagreed with the statement. In Israel all the participants oppose this statement. They think that Science centres contribute and encourage creativity and that they also contribute to the knowledge and information society, where knowledge is a cultural value. A suggestion is made that developing and contributing to the knowledge society should be part of the SC agenda.

In South Africa and Australia opinions were divided. In South Africa the teacher representatives thought that this area needs to be researched before they can comment fully, and considered that there are relatively few programs within SCs which actually promote creativity; there is more in the way of hand-on activities. The other groups distinguished between "enough" in terms of existing SC capacity in the country and the need for the provision of more SCs. SCs do what they can but there is a very great need for innovation and creativity in South Africa which they cannot meet. In Australia this statement caused reflection in all the participants. The consensus appeared to be that the science centres may be limited by their available resourcing and also their original goals and objectives, however they are still part of an integrated solution. Some thought they don't directly contribute at all, but indirectly they do by motivating students to perhaps consider this as a career or an interest. In Denmark, Portugal and Colombia most participants rather agreed with the statement. Several Danish representatives pointed out that SCs do not do enough for pupils to be creative. They also stated that there are not enough SCs in terms of accessibility. Some teachers even think that many school projects are really more creative than what happens at SCs. The SC representatives admit that for most exhibitions enhancing creativity is not the case but their goal is to be a knowledge intermediary. Both Colombian teachers and representatives of science centres said that the promotion and development of creativity is an educational long term process. They see it difficult to achieve in the short time of a visit. From this perspective, the school or activities such as science clubs and afterschool programs are better able to develop creativity. In Portugal all participants feel that Science centres are more effective as drivers for knowledge society, when compared with their impact in creativity and innovation and that there is scope for improvement in this area.

This statement was not discussed in Italy.

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.

Virtually all the participants (AU, BEnl, CL, CO, IL, IT, PT, TH, ZA) agreed with this statement. In the latter country (ZA) the discussion of this statement was brief. There was general agreement, and all the teacher representatives agreed that sports, chess etc. can achieve the skills referred to. The corporation representatives considered that the list of soft skills provided are not science-specific. There was also unanimous agreement with this statement in Australia. Many participants in several countries (AU, BEnl, CL, IT, ZA) found it obvious that one can reach soft skills via other extracurricular activities like sports, arts appreciation etc. Some (BEnl) even thought that this statement is irrelevant and that it is wrong to compartmentalise soft skills as they can be acquired everywhere. They pointed out that one can acquire soft skills like teambuilding in any context where several people try to reach one common goal through cooperative activities. They added that soft skills such as problem solving and teamwork that have been acquired in a certain context (e.g. sports), can be used and will probably be strengthened in another context (arts or sciences). Thus, students can acquire a wide range of soft skills and when using these soft skills in different contexts they will become more and more skilled. Also in Italy the participants stated that sports are a good situation in which to develop soft skills. Especially team sports help develop team work and reactions to difficult situations while keeping in mind a specific objective. Nevertheless one participant pointed out that the difference with sports is that, where there is a collaboration between school and

museum, the students will be more aware of the development of their personal skills. In Chile most participants also believed that one can develop soft skills practicing sports, dance, with friends, etc. and that some skill development is exclusive of one activity or specific centres. With regard to soft skills both Colombian teachers and representatives of science centres noted that there are other curricular areas in which you can learn them. They even recognized that activities such as sport or art may be more conducive for learning soft skills, but pointed out that science centres and science in general, can teach various soft skills important for life such as those related to problem solving and logical thinking.

However, some participants in those countries thought that a technological project pre-eminently offers opportunities to acquire soft skills as one needs a wide range of skills to achieve such a project (BEnl) or that some skills like "sense of wonder", "interest to discover" or "how to understand cause- effect" by learning by doing, are developed in science centres. The skills one acquires in one context are complementary to those acquired in another context (CL). In Portugal participants also thought that critical thinking and inquiry, for example, are best served by science centres as informal science learning environment and in Thailand participants referred to communication skills, interpersonal skills and social skills that are acquired in Science centres and are important for scientists. As well in Israel as in Flanders participants pointed out that it is beneficial to use Science centres to develop soft skills, as the centres enable students, especially nerds, to receive the opportunity to stand out and thrive.

Industry stakeholders in Portugal and Flanders tend to insist on the need for complementarity between soft skills and subject-related competences.

In Denmark and Korea the discussion was more about the importance of soft skills as where to acquire them. There was no discussion about acquiring skills in other extra-curricular contexts. The Danish participants pointed out that it does not matter how much you know about a subject, if you cannot communicate it. They had also noticed that exhibitions that require cooperation arouse interest. Moreover they also indicated the importance of teaching soft skills at school. This was also pointed out by participants in other countries (BEnl, CL).

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 centres can play a role.

In several countries (AU, BEnl, DK, IL, ZA) the majority of the participants disagreed with the statement. On the contrary they think that by focusing on soft skills children will learn better and the test results might also improve. Once again the participants in these countries think that schools and science centres have complementary roles as far as the acquisition of soft skills is concerned. In Australia the teachers even vehemently disagreed with the opinions of schools being judgemental and they pointed out that they were developing the skills for the future. They also stated that when content and soft skills are taught well in schools, then this will enhance the performance of pupils in certain tests like the PISA are going to improve. They also commented that they had seen an increase in the level of importance of these skills in terms of helping the students academically. The other participants agreed as long as content and soft skills are taught in parallel. The Israeli participants also think that the opposite is true - focusing on soft skills in schools will only help learning. The essence of education, beyond gaining knowledge, is acquiring soft skills and behaviour. Most Flemish participants also strongly disagreed with the statement and pointed out that both soft and hard skills have to be taught, otherwise children will not acquire the skills they need for life after school. They are convinced that by focusing on soft skills the children will better remember what they have been taught. Maybe less subject matter will be covered but pupils will know better what they have learned. A few participants think that especially in general secondary schools it might nevertheless be good to have collaboration between science centres and schools in order to be able to cover all subject matter and focus on soft skills as well. Also in Denmark the participants were convinced that hard and soft skills cannot be separated. Focusing on soft skills helps to give higher marks to both the weak and the skilled students. Moreover when hiring employees, employers will assume that the hard skills are present and they will hire the candidate with the best soft skills. In South Africa there was general agreement that soft skills should be taught throughout life; they come from personal learning which can happen anywhere. SCs can play a part in imparting soft skills, but it is not their main focus; they can assist in developing certain skills like accuracy, communication, creativity, critical thinking. There are other soft skills (not specified, but probably media literacy, self-reliance etc.) that SCs cannot assist with developing. Although in Chile opinions were slightly divided most participants disagreed with the statement. Whereas a few thought the statement to be absolutely true and added that soft skills are difficult to measure, others disagreed, because many of these soft skills are developed in parallel with "hard" skills. Some especially disagreed with the part of the statement that says "that's where science centres can play a role" as they thought it was not the duty of the science centre or museum to develop these soft skills. They also added that it made them question their education system. The school programme includes developing of soft skills, and evaluating them. However, the teachers lack the abilities, preparation and methodology to develop and promote this kind of skills

At first teachers in Italy all agreed with the statement, stating that in schools teachers don't have enough time to think about soft skills. They remark that the national standards impose a crazy pace and the teachers need to transmit many contents to their students. However, after discussing with the other participants for a while they then began thinking that the best thing would be to integrate the teaching and evaluation of these skills throughout their programs, during all course years. They suggested they might be able to do it by teaching science with a methodology that is closer to the "open method" adopted by the Museum, by working in an interdisciplinary way or by offering students the possibility to present their studies and work thus helping them develop their personal ways to deal with things, understand them and communicate them. In Colombia the focus group with teachers revealed that, at this moment, there is a struggle between the various actors in the educational system around the issue of development of soft skills. While teaching and developing soft skills is considered one of the objectives to be achieved through education, quality guidelines currently promote teaching concepts as the priority of schools and the time teachers spend in the development of social aspects of the child is undervalued. The participants thought that science centres could be seen as spaces that can fill this gap in educational institutions around the soft skills, but they pointed out that some decision makers in schools might consider field trips as superfluous and a waste of time.

In Korea, Thailand and Portugal the pressure of exams is such that schools do not focus on soft skills, as these are hardly assessed. In Korea and Thailand school education is directly related to grades, and elements such as teamwork may not be too helpful in improving school grades. Schools are measured by 'examination' therefore the time is used to follow the curriculum. Also in Portugal 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 In these three countries participants felt that school education could be complemented by classes at the science centre that are not related to school grades.

However, the Portuguese participants pointed out that while recognizing the advantages of informal learning environments to address transversal skills, they also realise that the absence of assessment of the outcomes of informal learning has a double negative effect. On the one hand, because there 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. Therefore the role of science centres in the acquisition of soft skills is clearly undermined, no matter how equipped they are for the development of soft skills.

10. Visiting a science centre has little impact on whether students follow careers in STEM.

Although most participants in Australia, Flanders and Denmark agreed with this statement they had balanced opinions on the impact of visits to a science centre on science careers. In Australia the participants largely agreed with the statement. Personal interest in a topic was identified as important in determining career choice, but not necessarily the sole determining factor. Also inspiring teachers were mentioned as being consistently identified by high achieving scientists as what motivated them to become a scientist. In fact they pointed out that it's a collaborative effort between teachers, parents, science centres, peers, tv shows... The benefits of science centres in this context were seen as "value adding" to everything else that is happening in a school. Science centres can share possibilities of some career options rather than creating scientists. In Flanders most participants thought that visiting a science centre can have an impact on whether students follow careers in STEM. However, this impact can also be negative if the students meet the wrong role models. Most of them agree that generally a visit to a science centre has little impact on the choice of students for a STEM career unless this visit takes place when they are at a key moment in their lives like going to secondary or higher education or when they meet scientists that make an impression on them. At that moment students might choose for a STEM-career if the experience is positive. Also more frequent visits to science centres or STEM-workshops can have an impact. It is therefore important to see to it that the students meet the right role models or have a positive experience. The teachers and SC representatives in Colombia also shared the opinion that vocational stimulation of STEM career can be done in science centres if there is a continuous experience especially for middle and high school students. Nevertheless, some teachers thought that visiting a science centre may have long-term impact with regard to career decision making even in younger children in sporadic visits, especially those coming from communities with fewer opportunities.

In Denmark the participants started by saying that this relationship cannot be measured. They pointed out, among other things, that it also depends on factors such as heredity and environment, and whether you have an inspiring teacher. Several participants thought that the media had a bigger influence on the career choice of young people.

In Chile, Portugal and Thailand and South Africa opinions were divided. In Chile some participants thought that visiting science centres has little impact on whether students follow careers in STEM taking into account the fact that there are more science centres and fewer science students. Others think it has an impact because the scientists they know have decided to follow a career in science after they visited a science centre or museum.

They also pointed out that the facilitators in the museum are very important as they can be seen as role models. Science communicators in Portugal 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. 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. Also in South Africa there were varied opinions. First of all this topic needs more research. There are numerous factors which impact on whether students follow careers in STEM; early life, schooling, visits to (e.g.) SCs and other contexts of informal learning. But also just children's general life experience. The SC representatives would like to believe that SCs do have impact on careers, but this is not the primary role of SCs. There is only anecdotal evidence that visits might have an impact on the choice of studies. They also admitted that there is a general lack of career guidance of school students in ZA schools. In Thailand some pointed out that Science museums and centres create inspiration and affect the decision for future careers whereas others thought that Science museums and centres do inspire children's interest in learning science, but the decision for future career actually depends on the social value and monetary compensation or wage.

In Korea the participants more or less disagreed with the statement. There are those children who naturally develop an interest in science as a career after meeting the scientists. Extracurricular science education offers an opportunity for students to find out for themselves if a STEM career is suitable for them or not and perhaps choose a career in science in the long term. Although extracurricular science education helps broaden the range of career choices, it is schools that are responsible for in-depth education.

In Israel everyone disagreed with this statement. Long interactions and even short visits to Science Centres have the potential to impact the students, and eventually crystallize to selecting STEM careers.

This statement was not discussed in Italy.

11. Science centres do trigger the attention of children, but do not invest in learning processes with real long term impact

Opinions between the participants of the focus groups varied in all countries (AU, BEnl, CL, CO, DK,, IT, KR, PT, TH and ZA) except Israel. In the latter country the participants pointed out that short-term activities in SC generate initial interest and the understanding of a subject whereas long term activities in SC have a clear investment for significant learning processes.

One of the difficulties in this respect was the lack of a definition for science centre. In certain countries the participants were only speaking about a museum where children (and adults) might come on a one-off basis whereas in other countries the discussion was only about extracurricular science classes attended on a voluntary basis. Some focus groups made the distinction between on the one hand science museums or science centres which children only visit occasionally and on the other hand science clubs or science classes that children attend on a voluntary and regular basis. It is obvious that as far as learning processes with long term impact are concerned, there will be a considerable difference in impact between these different types of science centres.

In Australia all participants pointed out that the trigger given by a science centre visit to a child is highly dependent upon the adult accompanying them. Some emphasised that the role of science centres was to spark interest rather than 'teach' content. Others referred to the potential for long-term 'impact' a visit to a SC can have. The problem with defining 'impact' in this context was also touched upon. Probably the main impact SCs have is the connection between the science centre exhibits and real life. In Flanders the distinction was made between "traditional SCs" and science academies or science clubs. Most participants agreed with the statement regarding "traditional" science centres as they do trigger the attention of children, but cannot invest in learning processes with real long term impact. In contrast they thought that STEM-academies or similar initiatives do invest in long-term learning processes. They also agreed that science centres can indirectly have an impact on the learning processes of pupils through the PD for teachers and the learning materials that are developed. In Colombia teachers pointed out that regarding the long-term impact of science centres, there are various obstacles and difficulties for schools to have a permanent relationship with science centres (economic, bureaucratic, lack of awareness about the possibilities of science centres), so impact in many cases is reduced to the possibilities that one single visit can offer to the students coming. However, the representatives of the science centres remarked that SC have invested, time, money and human resources to improve learning opportunities offered to their audiences. Although it is noted that to have a big impact it is necessary to develop an educational process both within the museum and outside of it, they recognize that in fact there is an impact with the visit to a science centre. In Chile the participants thought it was not possible for a science museum to invest in long term processes. However, several participants thought that science centres can have an "emotional" impact and leave a mark or have an impact when the SC is visited systematically. Moreover they could have an impact on the long-term learning processes through the teachers who are seen as mediators between the SC and the children.

Likewise the participants in Denmark pointed out that it is not either or. The primary investment of the SC is to arouse curiosity and plant seeds. This curiosity aroused at the SC can have a long-term impact. Although SCs do not invest in long-term objectives at the exhibition, they do it, for example through learning materials developed for the teachers. They also regarded the teachers as mediators who hold the responsibility for implementing the long-term goals. SC representatives in Italy pointed out that they always try to have a long term impact but in order to do this they need the collaboration of schools, the possibility to work on themes that are relevant to students, the resources to develop ad hoc projects with individual teachers. Also here the importance of teachers to have a long term impact was stressed and that is why the Museum organised teacher training. Although the primary objective of the Everyday science classes in Korea is to help children become more interested in science they also help children to experience the science that scientists study and deal with. Once again the Korean representatives regret that in Korea science classes at school mainly focuses on theories for the university entrance examination. In South Africa the participants agreed that the role of the SC is to plant a seed of interest rather than "invest in learning processes with real long term impact". There were different opinions, as the term "real long term impact" was unclear. Some thought that the fact that people remember particular exhibits long after their visit – can be regarded as 'long term impact'.

In Portugal there is an overall feeling among all participants that science centres 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. Teachers, representatives from industry and some science communicators tend to look at science centres as environments designed for "short term" activities, with a focus on triggering interest and excitement. However, some other science communicators refuse the idea of science centres as learning environments designed solely to boost children's 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.

3. conclusions

3.1. Conclusions PER STATEMENT

1. In most countries participants feel that children should enjoy science centres and that teachers or parents should let them explore and experience by themselves. However, most of them think that a visit to a science centre should be more than just fun especially when visits are carried out in a school context. In a school context the visits to the science centre should be prepared and there should also be a feed-back or follow-up to maximise the impact. They also added that enjoying does not exclude learning. In Australia the participants wanted a middle ground because they were in large agreement that SCs are different to schools, mainly because of the element of 'fun'. Although participants also acknowledged that school should also be enjoyed, and enjoyable, both settings have different purposes and functions. In Korea the participants pointed out that in their SC children learned hands on and enjoyed it. In South Africa the context is different and SCs are often turned into schools because of the lack of resources in schools.

2. In all the countries concerned participants disagreed that science centres work better for boys than for girls. Most participants find it a misogynist statement and rather a societal issue. They also pointed out that every child is an individual, regardless of his or her gender. Especially at a young age teachers see no difference at all, sometimes girls are even more interested than boys. Nevertheless they point out that especially in secondary schools the scientific interest of boys is different from that of girls and girls rarely choose STEM-studies. Several participants agree that society expects girls to make a different choice and that boys and girls want to comply with the image that is expected of them.

3. In Chile, Columbia, Korea and South Africa most participants agree that schools have to learn more from the science centres rather than the other way round. In Chile there are several reasons for this: the structure of the classrooms, the lack of resources and most of all the lack of preparation of the teachers to new didactical approaches. In Korea the main reason were safety issues and in South Africa a lack of resources and skilled teachers. The majority of the participants in Denmark, Israel, Portugal and Thailand also more or less agreed with the statement because SCs can offer different teaching approaches especially as far as inquiry based science education is concerned.

Most participants in Flanders and Australia disagree with this statement. Participants think that there must be interaction and feedback between schools and science centres and that the starting point must be that they can learn from each other. Both are compatible and complementary. They also added that learning is not about being better than but about interaction and learning from each other. They stress there should be interaction between schools and science centres and that in order to enhance this collaboration feedback and interaction between the two are very important.

Although there were divided opinions on this statement in the different countries concerned, most participant to

the focus groups think that schools and science centres should be complementary and that what is being offered in science centres should be additional to what is done in schools. Schools can learn from science centres especially as far as didactical approaches are concerned and science centres can learn from schools about their target audiences. In several countries it was pointed out that science centres have more resources than schools and that they have the possibility to exhibit and demonstrate phenomena the pupils have learned about at school.

4. On this item the participants in most focus groups have slightly divided opinions. Some suggested that "promote" is too strong a word, but that SCs can provide guidance on the range of opportunities available in science and technology. Most of them agreed that it is their role to inform children about and motivate them for a wide range of science careers and that they should be showcasing them through role models. They should do this implicitly rather than explicitly. Only in Israel all participants disagreed. They even thought that promoting science careers should be part of the SC's agenda.

5. In most countries participants disagreed with the statement that science centres rarely focus on the relationship between science and industry. The application of the science to the industry was a recurring theme in these discussions as what is most commonly shown in science centres, rather than industry specific exhibits and exhibitions. However, as well in Australia as in Chile it was pointed out that a balance needs to be struck and the ethical dimension has to be focused on when working with industry. The relationship between science centres is a complicated one in terms of conflict of interests. Being sponsored by industry should not impede the science centre to talk about the environmental impact of certain industries or the corporate responsibility a company has. In BEnl and DK opinions were divided. Most teachers in Flanders and Denmark thought that the link is not always obvious whereas corporate participants in Flanders thought that most science centres do focus on this relationship. Some Danish participants even voiced the opinion that explicitly emphasizing the link between SCs and industry is not attractive to visitors. In Colombia and Portugal participants agree with the statement and recognize that science centres are not doing enough to explore the connections between science, business and industry. Also here a certain consensus was found over all focus groups as the participants (of all the focus groups) agreed that there should be a link, especially to jobs and applications in industry.

6. Although the participants in the different countries concerned have divided opinions on whether students acquire skills in science centres which are highly beneficial for their lives after school there is also a certain consensus. Most participants think that just one visit to a science centre will not have an impact on the soft skills or competences of young children as acquiring skills is a long process. However the visit might be a step in acquiring these skills for life after school. Most participants think that it depends on the kind of science centre or activity and on the duration or frequency of the visits whether children acquire skills. As different kinds of SCs were involved in the project the divided opinions rather related to the kind of SC than to real differences in opinion. If there is a certain frequency as in workshop or in clubs where children meet on a regular basis, then children can acquire skills and competences that are highly beneficial for life after school. Especially for children from less privileged families this can be an opportunity to acquire skills that are not nurtured at home. All participants agreed that a one off visit will rarely have an impact on the skills of the children.

7. In several countries there was a discussion about the word "enough". Some thought the word was too ambitious, others did not know whether the word "enough" referred to capacity or the work being done to enhance creativity. Opinions are somewhat divided on this statement. Most participants in Flanders, Chili, Israel, Korea and Thailand disagree with the statement and think that science centres do enough in the way of promoting creativity, innovation and in contributing to a knowledge society and some even think that no science centre can survive nowadays unless it promotes creativity and innovation. However, some participants think that science centres don't do enough especially as far as innovation and the knowledge society are concerned. In Australia and South Africa SCs do as much as they can to enhance creativity but they are faced with limited resources. In Denmark, Colombia and Portugal most participants agree with the statement as they think that SCs don't do enough as far as creativity and innovation are concerned.

8. Virtually all the participants found it obvious that the soft skills that one aims to achieve are important, but that these can also be reached via other (extracurricular) activities like sports, arts appreciation, scouting etc. They also pointed out that some soft skills might be more easily acquired in a particular context. Moreover the soft skills acquired in one context can strengthen the skills acquired in another context. Several participants also pointed out the importance of teaching soft skills at school.

9. In most countries the participants disagreed with the statement that focusing on the soft skills in schools will lower the results in test scores by taking time away from tested skills. Most agree that focusing on soft skills will even improve test results on the condition that hard skills are taught in parallel with soft skills. In Chile the participants particularly disagreed with the fact that teaching soft skills would be the role of the SC. In Italy the participants initially agreed with the statement but as the discussion went on they were convinced that by teaching in a different way they could focus on soft

skills and improve test results as well. However, in Korea, Portugal and Thailand where the education system is totally focused on grades and on examination results the participants agreed with the statement.

10. In many countries the participants pointed out that there are no data to substantiate that visiting a science centre has little impact on whether students follow careers in STEM. Most participants in Australia, Flanders, Denmark and Thailand agreed with the statement and thought that visiting a science centre has little impact on whether students follow careers in STEM. They pointed out that science centres are only one factor amongst many to determine the career choice of young people. The impact that teachers, parents or even the media have might even be more important. In Chile, Colombia, Korea, Portugal and South Africa, opinions were more divided. Meeting positive role models was indicated as a contributing factor. The only country where all participants disagreed with the statement as they thought Science centres definitely had an impact on the choice of science careers was Israel.

11. In all countries concerned the participants agreed that science centres do trigger the attention of children. However regarding the long-term impact on learning processes the opinions were more varied. Participants agreed that most sciences centres cannot invest directly in the long-term learning processes of the children but in several countries reference was made to the learning materials and PD courses developed for the teachers. The SCs thus indirectly invest in the learning processes with a long-term impact. Virtually all the participants regarded the teachers as mediators between the SC and the children.

3.2. Conclusions on the Role Of SCience centres in the Acquisition of soft skills

The primary objective of the study was to find out how science centres could enhance the acquisition of soft skills. Therefore, in the paragraphs that follow we summarise the ideas of the participants on the acquisition of soft skills in science or technology centres.

In all countries concerned the participants pointed out that soft skills have become increasingly important for scientists and technologists. They referred especially to communication skills but also to team-work.

Acquiring soft skills is a lengthy process that requires time and one cannot expect young people to acquire these skills just by one single visit to a science centre. In this context it is also important to understand and define the role of the science centre.

If only 'traditional' science/technology centres and museums that are visited for the day are taken into account, then most participants agree that what the science centres can do regarding the acquisition of soft skills is rather limited (AU, BEnl, CO, CL, DK, IT, KR, ZA). The visit might just trigger or stimulate soft skills such as creativity, problem solving, communication skills, team-work etc. If the science centres want these visits to be effective they have to collaborate with teachers or even parents. In many countries (AU, BEnl, CL, DK, IT, ZA), teachers are seen as mediators between the SC and the pupils or students. That's why the Science centres develop courses for teachers (BEnl, CL, IT, PT) or learning/teaching materials (AU, BEnl, DK,PT). In Flanders they even suggested a roadmap or pathway for skills development to be designed in collaboration with schools.

It is obvious that SC initiatives where collaborative workshops are organised for children on a regular basis will contribute much more to soft skills development because the experience is long-lasting or repeated. Especially children from less privileged families or weak students acquire soft skills actively (BEnl, CO, KR) in such workshops. Even occasional visits might trigger the soft skills of less privileged children (CO).

The overall discussion on soft skill development led to comments from nearly all participants in all the countries concerned on the need for the current, and future, scientists to be able to clearly communicate about their work but also the need to be able to work together as scientists are no longer working in isolation.

Although virtually all participants agreed that these soft skills can also be acquired in many other contexts, some are convinced that for instance working on a technological project pre-eminently offers opportunities to acquire soft skills as one needs a wide range of skills to achieve such a project. Others think that depending on the interest and the talents of the children they will acquire these soft skills more easily either when practicing sports, when visiting a science centres or when participating in a technological project. Soft skills that have been acquired in a certain context can be used and will probably be strengthened in another context. The key is often the collaboration between school and science centre/museum to make the students aware of their own skills and of the possibility to spend them in different contexts.

Most participants (AU, BEnl, CL, DK, IL, ZA) also agreed that by focusing on soft skills in schools, children will learn better and the test results might also improve, science centres can play a complementary role especially as far as problem solving and creative skills are concerned as pupils can experiment in a "safe" environment where they can fail. Therefore the participants stress the importance of collaboration between science centres and schools in the acquisition of soft skills. In countries where exams

are just focusing on knowledge (KR, PT, TH) soft skills are being neglected in schools. In these countries the role that Science centres play in the acquisition of 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.

In this respect the Israeli participants discussed an additional statement on Catalysing STEM Innovations Skills in Informal Learning. All participants agreed that exposure to STEM in Science centres is a catalyst for the acquisition of skills. Such a catalyst will enhance formal learning. On the other hand formal learning is needed to achieve the outcomes desired. In fact formal and informal Science Education feed each other and the partition between the two is problematic and grating. Science centres have a role to play to strengthen innovation skills for STEM.

3.3. Advantages of informal learning in science centres and musea

The participants all mentioned a number of advantages of informal learning in science centres

1. In science centres children can experiment in a "safe", out-of-school learning environment without being assessed or even guided and without fear of failing. This allows for learning in a relaxed and unthreatening context which often assists with sparking interest and passion in STEM (AU, BEnl, IL, PT ZA). The centres can trigger the children's motivation for and interest in STEM by allowing them to engage in experiences and activities that are not always possible at school and therefore present an added value. Moreover 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.

2. Some demonstrations in the science centres also combine fun and learning inducing excitement and motivation to learn (AU, BEnl, CO, CL, DK, KR, PT, TH). They're fun, they're hands on implementing the systematic knowledge of formal education and most of all they show how experiments and phenomena can be applied to a context, to a real-life situation.

3. The participants also pointed that an important advantage of science centres and science museums is that they have resources that schools do not have and can thus show exhibits that are fascinating and amazing (BEnl, ZA). The science centres are also able to support STEM activities in very creative and innovative ways. This means that participants can be exposed to the very latest innovations or discoveries and their interest in current events can be ignited and sustained (BEnl, CO, CL, DK, ZA). SCs are also more likely to innovate in educational methods than schools and have flexibility to decide about contents and pedagogical approaches. Pedagogical innovation is perceived difficult to do in schools because of restrictions in curriculum design oriented to perform well in national and international assessments (CO).

4. The interdisciplinary nature of many science centre activities provides a good ground for the development of critical thinking, team work, inquiry methods and other transversal skills which are essential for lifelong learning of science. Especially in STEM-academies, STEM-clubs or other extra-curricular science classes or projects (BEnl, KR, IT, ZA) children who are interested in STEM can experiment in an out-of-school environment on a regular basis. Children meet with others who have the same interest and passion and acquire soft skills trying to find solutions for problems and communicating about them with their peers. The impact on as well the hard as soft skills and learning processes of the children will obviously be more important than after just a one-off visit to a SC.

5. Science centres are a privileged partner for teachers and schools (AU, BEnl, CO, CL, DK, IT, ZA), especially but not only as far as STEM-subjects are concerned. They can offer professional development courses for teachers and develop innovative learning materials (AU, BEnl, CL, DK, IT, PT). They can also inspire teachers and future teachers to use new methodologies in STEM and help them lay the foundations for long-term learning processes for as well soft as hard skills.

6. 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. 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 (DK, IL, PT). Thus science centres can also help inform young people about science careers although most participants to the focus groups think the impact might be related to the age of the visitors and also to the decisive moment in a student's life (BEnl, CO).

3.4. Challenges for informal stem education through science centres and science museums

The challenges that science centres face are often different according to the countries but also the kind of science centre concerned. Nevertheless some challenges were mentioned in most countries.

1. A challenge, but at the same time an opportunity that was mentioned by virtually all countries was the need for collaboration with schools. Schools and teachers were virtually always seen as privileged partners. The expectation in virtually all countries is that science centres should be spaces that complement classroom training. Therefore learning pathways should be proposed that articulate formal with informal education in order to generate experiences linked to the dynamics of the school without limiting the flexibility and the opportunity of free exploration during the visit. The only country where collaboration with schools seems to be virtually impossible is Korea because of the focus in schools on theoretical knowledge and the importance of the school grade system. However, in the few cases (in KR) where the science centre managed to collaborate with schools the reactions were very positive.

2. If science centres want to have an impact on the acquisition of soft skills, they should not only collaborate with schools (and especially with teachers) but also with other stakeholders in STEM such as parents, teacher training institutions, the local community etc. They should also be more responsive to local community's needs, in ways that stimulate active partnerships with key players in business and industry.

3. Science centres can also contribute to the acquisition of soft skills by developing a proficient methodology that can make the most of the short time of visits made and by providing programmes that promote learning experiences with a long standing impact of their learning outcomes. However, it is generally thought that the possible impact of SC experiences as well on the development of soft skills as on possible career choices in STEM can only be enhanced by focusing more on long-term, repeated or regular activities such as afterschool programs and science clubs that generate a real long-term impact. Especially in countries where soft skills are not assessed, science centres should pave the way by introducing assessment methods which are better adapted to informal science learning activities and environments.

4. In order to enhance the impact of the visits science centres should also organise professional development for teachers and develop teaching or learning materials based on the needs of the schools. This is already the case in a number of countries (AU, BEnl, CL, DK, IT, PT) but should be further developed. Also the use of sophisticated scientific equipment by schools, made available by the SC should be possible (BEnl) as well as the collaboration with teacher training institutions. In several countries the necessity for SC to organise professional development for the science communicators or explainers (already the case in AU) was also mentioned.

5. Although a number of participants think that science centres should not explicitly promote scientific and technical careers they virtually all think that science centres should inform students, teachers and parents about a wide range of scientific and technical careers and about the existing links between science, technology and industry by focusing more on the purpose of science and technology.

6. According to the participants another challenge for science centres and museums is to address specific individual needs of learners, by recognizing and addressing diversity in the students' learning styles, skills and backgrounds. Thus they should on the one hand provide activities for children of less privileged families (AU, BEnl, CO, KR) as regular visits to a SC seem to be especially beneficial for these children but also organise workshops for gifted children. Science centres should also do more for the age range of 14-18-year-olds. By offering a wider range of activities for this age group they might possibly attract more girls to STEM-studies and more students to STEM careers. Moreover there is still room to improve inclusiveness and avoid reproducing gender-related stereotypes. Lastly some participants stressed that in order to be inclusive science centres should be accessible also for children living in remote areas. (DK).

7. Science and technology centres should contribute more to the knowledge society and to better scientific literacy. Therefore they must enlarge their target audiences and contribute to bridging the increasing gap between those who produce scientific knowledge and those who are impacted by its applications in everyday life. They should also promote scientific citizenship and engage the public in a rational and critical debate about science and technology.

8. Some participants also think that the science centres do not offer enough opportunities for the children to experiment by themselves. Therefore they should shift the focus of their activity in science communication from the popularization of science to a more active participation of citizens in science.

In South Africa there are some specific challenges for informal STEM education through science centres and science museums. Whilst some of ZA's science centres are better off than others, all of them will indicate that their greatest challenge is funding, or the lack of it. The other challenge that seriously affects all science centres is that of human resources. Often managers spend much time training new, and old, staff - only to find that they move on to other jobs. Indeed, training is an ongoing activity for science centre managers. Another challenge is the inability to generate new exhibitions on a regular basis. The costs are prohibitive and this means that the centres are not refreshed at a rate that will generate ongoing interest from the communities they serve. The science centres in South Africa also sometimes take up the role of schools where (i) teachers may not be fully qualified to teach science (ii) there is lack of equipment (iii) there is low morale and teachers are not fully committed. However the science centres do not see it as their role.

3.5. Consensus and differences between the countries concerned

1. It is surprising that although the socio-economic background of the countries studied is quite different, there is a virtual consensus on a number of statements.

Everywhere the participants thought that children should first of all enjoy science centres. There were some slight differences in opinion with the participants in Australia focusing on the fact that it should also be a learning experience, the Korean participants stressing the playful and enjoyable way of learning and the South Africans regretting the fact that SCs are often obliged to take on the role of schools because of the lack of human and other resources in schools.

There is also a consensus on the gender issue with virtually all participants stressing that SCs work as well for boys as for girls. Where there were differences it was considered to be a societal issue. Nevertheless, virtually all participants thought that this societal issue had to be dealt with and the Colombian participants even suggested further research on the role of SCs and gender.

In all countries the participants thought that there should be a link with industry as the applications in industry are in fact the implementation of science and technology in real life. Some even thought that this relationship should be on top of the agenda of the Science centres. However on how this relation with industry should be developed opinions varied considerably.

2. On some other statements opinions varied as well within the countries as between the countries

As far as the role of SCs in promoting science careers is concerned, only two countries (CL, IL) entirely disagreed with the statement and thought that SCs should definitely promote science careers. In all the other countries opinions were more or less divided very often depending on the job or function of the participants. Many participants did not like the verb to promote but preferred to inform about science careers or even more subtly inspire young people and showcase opportunities or challenges (AU, BEnl, CO, KR). It is remarkable that in Columbia and South Africa teachers considered that promoting science careers is the role of a science centre whereas the SC communicators thought it was not their role. In both these countries the teachers referred to insufficient career guidance in schools. In contrast Flemish and Australian teachers were afraid that "promoting" science careers would have the opposite effect. In Denmark the participants pointed out that it was not the core role of SCs but that it could be a nice side effect.

In Australia, Italy, Korea and South-Africa the participants were convinced that students acquire skills in science centres which are highly beneficial for their lives after school whereas in other countries the opinions were much more divided and participants thought that Science centres were planting the seeds and that these had to be further developed elsewhere. Once again participants made the distinction between regular activities at a Science centre and occasional visits. However, the Italian participants pointed out that even a short visit could have a butterfly effect. Participants in all countries concerned (this statement was not discussed in Denmark and Korea) were unanimous to state that soft skills that are acquired in Science centres can also be acquired through other extra-curricular activities although for certain young

people Science centres or Science clubs work better.

3. There are considerable differences between the countries as to some of the statements

The statement about schools learning more about teaching science from science centres than the other way round received quite different reactions. In Flanders and Australia the participants disagreed and stated that schools and SCs can learn from each other. In Denmark the participants more or less agreed and stated that SCs can offer more specialised scientific knowledge. In all the other countries the participants agreed with the statement. Most of them referred to the methodology and more hands-on approach of the science centres. Nevertheless, all participants agreed that there should be more collaboration between schools and SCs. Only in Korea this seems to be virtually impossible because schools only focus on content for university entrance exams.

On the relationship with industry the opinions in the countries studied also varied considerably. Only in Colombia and Portugal participants completely agreed with the statement as participants thought that SCs rarely focus on the link with industry. For the Portuguese science centre stakeholder group this is a consequence of the school objectives, which leave out key sectors of society and also because of the attitude of science sectors towards industry. In contrast in several countries (AU, CL, IL, IT, KR, ZA) the majority totally disagreed with this statement although several participants pointed out that the application of science is what is most commonly shown in science centres, rather than industry specific exhibits and exhibitions. Very often this relationship derives from the funding coming from industry. Although the majority disagreed with the statement they also stressed that the ethical dimension should be taken into account. In Flanders and Denmark the participants had divided opinions. Although some thought that the link with industry was obvious other considered that it was more implicit and explicit.

The most striking differences were noted as far as the acquisition of soft skills was concerned. These differences can be explained by the importance the different education systems attach to soft skills. In Italy, Korea, Portugal and Thailand where the stress in schools is still virtually only on the acquisition of knowledge and on grades the participants considered that schools neither had the time nor the determination to focus on soft skills. They agreed with the statement that focusing on soft skills would lower test results and this was the role of the Science centres. Nevertheless the Portuguese remarked that as long as soft skills are not assessed it will be difficult to prove that visiting a Science centre enhances these skills. Also in Italy teachers at first agreed that because they have so much content to transfer there is no time to focus on soft skills in schools. However, participating teachers then began thinking that the best thing would be to integrate the teaching and evaluation of these skills throughout their programmes, during all course years. In contrast, the Australian, Flemish, Chilean, Danish, Israeli and South African participants largely agreed that focusing on soft skills will not lower the test results. Some Australian participants even pointed out the need of "explicitly and implicitly incorporating these skills into the classroom" as they had seen an increase in the level of importance of these skills in terms of helping the students academically. In Flanders especially primary and VET teachers referred to the assessment of soft skills and corporate stakeholders as well in Flanders as in Denmark stressed that soft skills were as important as hard skills when hiring employees and that they should be taught side by side. The Danish teachers thought that soft and hard skills cannot be separated. Likewise the Chilean teachers stated that the school programmes include the development of soft skills, and they also have to evaluate them. The Israeli participants were convinced that focusing on soft skills in schools will only help learning. The essence of education, beyond gaining knowledge, is acquiring soft skills and behaviour. Also the South African participants thought that soft skills should be taught throughout life. Regarding this issue, the Colombian teachers had divergent opinions, showing that there are some inconsistencies in discourses and policies about the objectives of education.

4. Recommendations

In order to be an effective environment for a broad base of young people to acquire innovation skills necessary to participate in the 21st century workforce the focus groups in Australia, Flanders, Colombia, Portugal and South Africa recommended the following:

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. Therefore learning pathways should be proposed that articulate formal with informal education in order to generate experiences linked to the dynamics of the school without limiting the flexibility and the opportunity of free exploration during the visit. Thus Science centres can be perceived as valuable experiences that complement curriculum activities and provide a different approach to learning that might help to improve the performance of teachers and students. Wherever necessary bureaucratic obstacles should be removed through the development of public policies that foster non-formal and informal education as something valuable.

Recommendation 2

Science centres and museums should **reach out to new target audiences** building on their prior experience, knowledge and specific learning needs. Learning experiences at the museum and science centre should address the diversity of learners such as children from less privileged families, older students, gifted children, parents, grandparents or organisers of holiday camps to see how they can help them maximise the impact of the visit to a science centre or museum. They should therefore 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.

Recommendation 3

Science centres and museums should also **diversify their organisation focusing more on regular activities rather than exhibits,** change the design of the exhibition in such a way that they also appeal to older students and that they are as interesting and appealing for teenage girls as boys. They should organise professional development of (future) teachers and school managers especially as far as IBSE is concerned, developing simple learning materials that teachers can use or can develop further, inform the public about careers in science and technology and showcasing the purpose of science in industry but also how science can contribute to solving the future needs of society such as the care for the aging population. Science centres could also have a repository of more expensive or sophisticated materials and tools that they could lend to schools or that schools can use on site.

Recommendation 4

Science centres and museums should focus on **human resources development of their managers and science facilitators** or communicators in order to prepare them for the challenges of the 21st century and the new tasks that Science centres should take on. Science communicators should be able to adapt their communication to the different target audiences, to tell passionate stories but also to substantiate a scientific theory when explaining experiments. They should also seek teacher input into their own program design, to ensure that the educational experiences from the formal and the informal are complementing each other and incorporating the best practice from each sector. In this respect science centres could also **participate in the continuous professional development of teachers and future teachers** in collaboration with teacher training institutions.

Recommendation 5

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. More research is especially needed to assess the impact of informal learning on soft skills and on gender. As a first step relevant data (e.g. on the age and gender of visitors to science centres) should be collected in order to enhance the policy and approach of science and technology centres. In order to assess the quality of informal science learning, as provided by museums and science centres, the latter should be subject to systematic educational research and peer-reviewed evaluation.

Recommendation 6

Authorities should make sure that **all children have the opportunity to visit a science centre**, attend a science/technology club or to be part of the newest developments on science in environments which are most accessible for them. Small science centres or mobile science centres/buses are a way to reach all children even those living in remote areas.

Recommendation 7

Science centres have a great potential to **foster innovation** in and out of school, especially in the development of soft skills, the flexibility and richness of the experiences provided by science centres is a great asset that communities have, nevertheless there is still a path of research and learning to follow in this issue. In this order of ideas, it is key to promote cooperation projects of research and innovation that would help the field as a whole to improve its impact in this direction.

Recommendation 8

In view of the above recommendations Science centres and museums should **engage in a constant dialogue with stakeholders** including students, teachers, science education researchers, scientific institutions, universities and education authorities to find out what their needs are and how the exhibits in the centre and the materials on the website or the activities of the science centre could be improved. By engaging in such a dialogue the science centres (and schools) will better understand their complementary role in the students' and teachers' acquisition of innovation skills for STEM (and other subjects).

Annexes

Annex 1: Protocol for the Focus groups

Participants will not be trained before the focus group.

Participation from corporations is crucial in this project. However, we don't need to have representatives who are familiar with science centres. We are looking for people explaining what skills they are expecting from the (STEM) workforce. The dynamic of the discussion may lead to have them express opinions.

The focus group discussion is led by a researcher that is familiar with the focus group techniques to make sure the protocol is respected; no single individual dominates the group; participants are properly invited to explain why they support a statement or not. Researcher will have to prepare well in advance with local organizer.

Focus group organizers will make sure that participants are properly informed about the project and have an understanding what they are part of. (Statements will not be disseminated in advance of the discussion).

Organizers will ask participants to sign an "informed consent" document on arrival.

It is also recommended that local report is shared with participants for control before it is send to ASTC.

Annex 2: ASTC international exploration initiative (Introductory text by Walter Staveloz)

Starting point

As part of the Association of Science and Technology Centers (ASTC) Innovation Initiative ASTC wants to explore how science centers can transition better youth from education to employment and give them the skills to be innovators when they get a job. ASTC bases itself on studies of the OECD that show that countries that achieve well in the PISA ranking (high achievement for science learning in schools) not necessarily have youth being interested in science or being creative with what they learn. On the other hand, we see that youth that shows creativity have been exposed to hands-on activities, groups works etc... things that science centers are doing better than the schools. On the other hand, school systems that include hands-on approaches and which place science in context seem to be more successful at motivating kids in science. The results seem to indicate that science centre type activities can contribute to increase students' motivation. ASTC wants therefore to explore how science center activity in different countries relate to what is done in schools (inspire teachers, etc.) and if there is any evidence of impact on motivation at all.

However, results differ from country to country and that is why ASTC want to explore, in some depth, how science center activity in different countries relate to what is done in schools. These outcomes are of extreme importance since motivation and creativity are core to what industry is expecting from youth to become part of the new innovation-based economy. Science centers could then become a central place to contribute to that larger objective.

When looking to those students who show interest, creativity and motivation for science it appears that they very likely have been confronted with science learning outside of schools. Learning techniques in these environments focus more on interdisciplinary approaches, problem solving, groups work, flexibility. A secondary effect may be that schools would be more inclined to send their students to a science centers if it appears that their chances for getting jobs increase. This could help the prestige of the school in its community. The question is: are science centers which provide this type of science learning more efficient in preparing kids for the knowledge economy? In other words we would like to test the hypothesis that ISE practices increase the soft skills that students need for the future workforce and that science center/museums should therefore become central or significant in STEM plans in most countries.

Definition of soft skills

Soft skills that literature shows are sought after by companies actively building the knowledge economy. Soft skills are behavioral competencies which are broadly applicable both in and outside the workplace. They include proficiencies such as communication skills (being able to communicate), conflict resolution and negotiation, personal effectiveness, creative problem solving, strategic thinking, team building, influencing skills, dependability and conscientiousness, to name a few. They are personal attributes that enhance an individual's interactions, social functioning, job performance and career prospects.

Example: the "soft" skills required for a doctor, would be empathy, understanding, active listening and a good bedside manner. The "hard" skills necessary for a doctor would include a vast comprehension of illnesses, the ability to interpret test results and symptoms, and a thorough understanding of anatomy and physiology.

Soft skills are often described by using terms often associated with abilities that can be practiced such as:

accuracy; aesthetic competence; empathy; exploration; considerateness; communication; consciousness; creativity; critical thinking; flexibility; initiative; leadership; media literacy; negotiation; open and constructive attitude; perseverance; respect; responsibility; self-consciousness; self-reliance; sociability; working together

Focus groups

ASTC wants focus groups in several countries in the world who will explore the situation for their own country to indicate that science centers type activities can contribute to increase students' motivation. The focus groups will explore how informal learning activities have the potential to make a positive impact on young people's engagement with science, technology, engineering and mathematics (STEM).

Expected outcomes

Fine tuning the question and finding additional resources that illustrate it, or indicate new orientation for research.

The result should inform an action research project by ASTC going through an NSF panel review at this moment that will try to illustrate and test the hypothesis over the next years.

As part of the preparation of this exploration the Flemish Department of Education is invited to be part of this international initiative that aims understand better how different countries perform in this regard[12]. We are asked to organize a two focus groups on these matters in our country.

Scenario of the focus groups

All groups will follow the same discussion mode which means to submit to the groups a series of 11 statements in the order that you will find them hereafter. The discussion will be following a protocol that is been established by a group of experts and that will be the same in every participating country. We have established the core of our scientific committee as follows:

Prof. Justin Dillon. Professor of science and environmental education. Head, Science and Technology Education Group (STEG). Department of Education and Professional Studies. King's College London.

- *Stephan Vincent-Lancrin*: Senior Analyst, Centre for Educational Research and Innovation, OECD (Paris)
- *Dr. Carmen Sánchez*, UNAM, Mexico.
- *Carlos Alves PhD*, Ciencia Viva. Portugal (Cambridge UK)
- *Dunon, Rita*, Department of Education Flanders-Belgium
- *Elaine Reynoso*, UNAM, Mexico
- *Rosalia Vargas*, Ciencia viva, Portugal
- *Dr Beverley* A. Damonse nrf.ac.za
- *Tony Lelliotte*, Tony.Lelliott@wits.ac.za
- *Derks, Anton*, Department of Education, Flanders-Belgium
- *Michael Peter*, Michael.Peter@sci-bono.co.za

[10] The participants at this date are (countries and corresponding science center): Flanders (Technopolis); Finland (Heureka); Denmark (Experimentarium); Italy (Leonardo Da Vinci); Portugal (Pavilion of Knowledge); South Africa (Sci-Bono); Mexico (Universum); Chili (MIM); Australia (ANU-Questacon); Korea; Thailand (NSM).

Participants will not be trained before the focus group. Participation from corporations is crucial in this project. However, we don't need to have representatives who are familiar with science centers. We are looking for people explaining what skills they are expecting from the (STEM) workforce. The dynamic of the discussion may lead to have them express opinions. The focus group discussion is lead by a researcher that is familiar with the focus group techniques to make sure the protocol is respected; no single individual dominates the group; participants are properly invited to explain why they support a statement or not. Researcher will have to prepare well in advance with local organizer.

Focus group organizers will make sure that participants are properly informed about the project and have an understanding what they are part of. (Statements will not be disseminated in advance of the discussion).

Organizers will ask participants to sign an "informed consent" document on arrival.

It is also recommended that the local report is shared with participants for control before it is send to ASTC.

Local organizers will keep a full audio recording of the session. The report should be a first analyses of the local discussion. The full report based on the collection and analyses of all contributions will be done by the colleagues of the Ministry of Education in Flanders. Final report will be submitted to all local organizers for correction and approval.

The participating organizations will not only be mentioned in the report, but also in many ASTC publications and conferences.

All participating countries will receive the global results of the worldwide research project and will be invited to become part of the " international virtual institute" that the project will create if funded and that will bring together experiences and best practices about innovation for education in informal settings. ASTC is also planning an international conference at the end of the project in which all participating organizations will be invited.

The report should be presented at two major international science education research conference in 2015 (NARST, Chicago: April) and ESERA (Finland - August). ASTC estimates that during the 2nd Science Center World Summit in Japan (2017) this project will be one of the key presentations.

Local organizers are free to use the collected information for their own purposes as long as it is presented as part of an international effort.

Ideally the reports of the groups should be finished around the end of December 2014 and definitely before the end of April 2015.

Statements to be discussed

1. We should let children just enjoy science centers, not turn centers into schools.
2. Science centers work better for boys than for girls.
3. Schools can learn more about teaching science from science centers than the other way round.
4. Science centers should not promote science careers - that's not their job.
5. Science centers rarely focus on the relationship between science and industry.
6. Students acquire skills in science centers which are highly beneficial for their lives after school.
7. Most science centers don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society.
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.
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.
10. Visiting a science center has little impact on whether students follow careers in STEM.
11. Science centers do trigger the attention of children, but do not invest in learning processes with real long term impact.

It occurs that 11 statements may be too many. It would mean 7-8 minutes/statement that possibly doesn't allow in depth exchanges. We therefore suggest that the first group should try this scenario out and share outcomes. If it appears not to be feasible, we need to cut down. We want to avoid a situation where groups decide on their own which statements are discussed based on time constraints.

Basic principles on organization of the focus groups (logistics)

Composition

- All groups should have representatives of the three major stakeholders: science teachers; science communicator professionals from science centers; people from corporations

Geographical distribution

- The list of countries is a representative one

Size

- We suggest 2 groups of about 6 to 8 people rather than one bigger group to avoid people not taking part

Venue

- The science centers members of ASTC in these countries should be the ideal venue.

Duration

- Focus groups should not last longer than 90 minutes (depends on the results of the try-out)

Facilitator

- The facilitator should be a researcher familiar with leading focus groups and with an understanding of the topic that is discussed. If needed a resource person knowing the topic could be present and make sure the discussion doesn't go off track.

Language

- All groups should be conducted in the local language. The session should be fully recorded. Report should be made in English.

Payments for participants

- Is up to each group, may have to pay transportation costs and stipend for teachers
- Small snack with coffee and tea should be served to make people feel comfortable

Deadlines

- See agreements with Walter Staveloz on the 10 th of July

Additional info: a session will be organized at the ASTC conference on Sunday morning 19 October 2014.

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Other websites used

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- http://www.betamentality.nl/?pid=4&page=Carri%E8re%20B%E8ta%27s
- http://www.technopolis.be/nl/fiche/zones-6-hoofdzones/xplora
- http://www.pedagooogia3000.info/
- https://coderdojo.com/about/#sthash.GK7pJieX.dpuf

1 Australia

1. REPORT ON AUSTRALIAN FOCUS GROUP

1.1. STEM in Australia and the role of science centres in STEM education

Australia is the only OECD country that does not have an implemented science or technology strategy[13]. This is despite the overwhelming acknowledgement and evidence of the importance of STEM to Australia's economic competitiveness. In particular, STEM in the schooling sector is suffering from a lack of a national coordinated approach, particularly with industry and university sectors[14]. Indeed there does appear to be a reliance on external providers, outside the formal education sector, to help support STEM education. For example the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Scientists in Schools program began creating partnerships between teachers and scientists and/or mathematicians in 2007 allowing students and teachers access to 'real' scientists and mathematicians, and vice versa[15]. Evaluations have consistently identified the value and strength of the program, and recommended continued support[16].

The Australian Chief Scientist outlines an objective in education and training as part of his proposed national STEM strategy, stating "Australian education, formal and informal, will prepare a skilled and dynamic STEM workforce, and lay the foundations for lifelong STEM literacy in the community"[12] (p. 20). Therefore the top Australian scientist sees a role for science centres in STEM education. This is not an unrealistic expectation. In a recent survey exploring Australians' engagement with science and technology, 66% of respondents reported visiting an informal STEM education setting within the last 12 months[17]. There is currently a large movement advocating for the development of a science centre in Western Sydney in New South Wales – the fastest growing region in Sydney – as a means of allowing students in that region to engage with science and take up careers in STEM fields, along with acting as a resource for teachers[18].

1.2. Existing Australian science centres – some examples

There are five states and two territories in Australia, and most have some form of science centre or museum. They vary greatly in size and structure from small regional centres through to those with state-wide responsibilities. Wollongong Science Centre and Planetarium in regional New South Wales is located in the Innovation Campus of the University of Wollongong. It serves the local region and is a venue for school and community group excursions. Scitech in Western Australia is in a commercial area of Perth amongst retail stores. Scitech provides outreach programs throughout Australia's largest state, visiting over 150,000 people and working directly with over 90% of the state's schools, teachers and students[19]. Australia has one national science and technology centre – Questacon – based in the Australian Capital Territory. Each year Questacon receives more than 400,000 visitors to its centre in Canberra, with its outreach programs reaching more than 110,000 additional people nationwide in some of the most remote regions. Its travelling exhibitions[20] reach a further 660,000 people nationally and internationally[21].

1.3. Definitions of terms used

'Exhibits' in the Australian context refer to the individual experiences and components that make up the larger exhibition. So a large exhibition may have around twenty exhibits within it, for example. This differs from other countries where exhibit refers to the entire collection of experiences and artefacts.

2. Introduction

2.1. Introduction of the focus group

This focus group was conducted at an Australian science centre with five participants. Pseudonyms are used here to maintain their confidentiality.

Two participants worked at the science centre; Susan, who works in the exhibition design side of centre operations, and Zoe a presenter of shows and programs.

Two participants were high school science and mathematics teachers.

[13] Office of the Chief Scientist (2014). Science, Technology, Engineering and Mathematics: Australia's Future. Australian Government, Canberra.
[14] Australian Industry Group (2015). Progressing STEM Skills in Australia , February 2015.
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[19] Scitech (2015). About Scitech – the Scitech story. Retrieved from http://www.scitech.org.au/business-centre/about-scitech/1623-about-us
[20] See section 1.3 regarding the potentially different interpretation of exhibit/exhibition.
[21] Commonwealth of Australia (2015). About Questacon. Retrieved from http://www.questacon.edu.au/about

They were Louise, an experienced teacher who has not taught for the last few years but will be returning to the classroom next year, and David, the head of mathematics at a local private single sex school.

Both teachers have worked in a range of education systems, public and private, co-ed and single sex.

The final participant was Alicia, representing the industry. Alicia works for a peak scientific body that has many networks and members in, and shared interests as, the industry community. Of approximately nine industry representative organisations that were contacted, only two were willing to assist. Alicia was the only industry representative who agreed to participate that was available within this time frame.

The moderator introduced the purpose of the focus group, as per the protocol and participant information sheet. It was emphasised that the focus group was soliciting their opinions about the role of science centres, based on their personal experience in relation to their occupations. Participants completed their informed consent forms, including providing their consent to be filmed, prior to the filming starting. The definition of soft skills, as defined by the project organisers, was provided in hard copy to the participants just prior to the first question about soft skills. Participants were not given access to the statements prior to the focus group.

Data collection: The focus group was video recorded and the moderator also took notes of the discussions. The moderator, based on the recording and the notes, prepared an abridged transcript. The entire focus group ran for one hour and twenty three minutes. All eleven statements were discussed by all participants.

2.2. The 11 statements (outcomes of focus group discussion)

The discussions about each statement will be summarised and presented in the order in which they were raised. The report will conclude with some overarching themes and trends.

We should let children just enjoy science centres, not turn centres into schools.

Participants wanted a 'middle ground' to this option and were in large agreement that science centres were different to schools, mainly because of the element of 'fun'. Both science centre participants (Susan and Zoe) acknowledged that science centres were much more 'free choice', visitors can choose what to interact with depending on their interests. Likewise, science centres don't have that same expectation of learning outcomes as schools do:

Zoe: *I feel that if you're talking about the difference between a science centre and a school. At school you have curriculum points you have to have, outcomes you are trying to achieve, whereas if you come to a science centre, you have fun, you definitely have educational outcomes but it's an exploration as you said [to Susan] it's more of what they're interested in a way that they're most suited to.*

Susan: *We have the luxury of not having to tick off curriculum links to justify our existence. We do provide curriculum links to support teachers but, well I'm speaking from an exhibition perspective – I can't speak for across the centre, but we tend to carry with us certain informal learning and science education principles that don't necessarily come directly from the curriculum or from a school environment.*

Although participants also acknowledged that school should also be enjoyed, and enjoyable, both settings have different purposes and functions. While Alicia, Zoe and David highlighted the 'fun' emphasis in science centres, Louise disagreed that this was a desirable attribute:

"*I'm very disappointed in the feeling that schools are not fun, that they're not exciting or engaging. That's what school should be about and therefore we should be working with science centres, taking advantage of the dramatic demonstrations but I'd also say the opposite. If science is only seen as fun, it stops students from thinking about the interaction of ideas and the applications of the creativity. Science is truly creative and if there is just the skimming over the dramatic effect without understanding them then that devalues the purpose of science. When I bring students [to science centres] I am rather 'anti' the fun. I identify things that I would like them to engage with, things that we have been doing in school, a few exhibits that I would like them to explore and then once we're back in class we discuss them further....I think science centres are very important, I think definitely they're fun but to say that they're only fun, nope I wouldn't even be considering fun in the list. I think that they truly need to do thinking critically and intellectually about why this [the demonstration] is so surprising...*

Alicia: *You raise some really good points but should science centres, I mean should a science centre be a school? What you're saying is that they work together.*

Louise: *Correct, yes so I guess it's a bit like what David was saying.*"

This notion of schools and science centres working together recurs often throughout the focus group, as will be discussed later.

Schools can learn more about teaching science from science centres than the other way around.

All participants noted that there was a mutual exchange of skills and ideas between science centre staff and teachers. Typical comments included noting that there was integration between the two sectors. The formal education sector, and the educators who work within, can gain a lot from seeing how science centres engage children in science, which can translate to a change in their teaching practice. Both David and Louise acknowledged either seeing colleagues change their practice or personally using things they have seen in science centres within their own classrooms. Alicia raised the potential impact of this exchange of learning in the development of teaching resources:

I think it's evolving. Like Science by Doing (Academy of Science school program) has learnt a lot from science centres in terms of drawing children in to self directed learning, into hands on engagement with science and to using multimedia presentations to interact with science in a different way. I guess it's the next evolution of a textbook in a way, although to say text book doesn't even begin to encapsulate it because it is so hands on and evolving but it is certainly learning from science centres but it doesn't mean that they're moving away from that core curriculum material. There's kind of an integration going on there.

Science centre staff also saw the teachers who attended programs assist each other in peer to peer learning. Zoe highlighted the role that teachers can play in science centre staff development:

I find that with teachers I can gain a lot on knowing how to interact with kindergarten age children, how to talk to kids. That's where I feel I can work most with teachers because they have all this stuff that they are trained to do and spent years getting really good at it, knowing the most effective ways to communicate with children.

Science centres work better for boys than girls.

This statement was disagreed with by all participants. The overarching consensus was that boys and girls may approach tasks or programs differently, and this could be due to the different developmental stages and cognitive development. There may be certain elements of a visit that appeal more to one gender than another (like Speedball – an exhibit which measures how fast you can throw and Susan says is very much an attractor for male visitors) however there is no difference in overall engagement between the genders.

All participants agreed that science centres should have enough variety to appeal to everyone, irrespective of gender, just like in school as David states:

a science centre should appeal equally because there is such variety of exhibits, styles and types. I've worked in a science centre, I've worked in all school systems in the ACT – government, private, co-ed, single sex - different kids will get different things out of it, and if you have that variety just like you do in a class room, you need to have that variety of activities to engage the students regardless of if they're a boy or a girl.

A science centre should not promote science careers – that's not their job.

All participants agreed that science centres should be showcasing opportunities and potential pathways for interested school children. David argued that schools should be doing much the same thing. Participants felt that there needed to be a balance and that raising awareness of opportunities is a good thing, so long as it was in a more implicit rather than explicit 'you should do this' manner. Zoe described how she usually achieves this:

We have a show that we do on insects and it's quite common for kids to come up and say "oh my gosh I love bugs so much" and then we say something to them like, "oh did you know that there is something called entomology?" and just talk to them about entomologists and the kinds of things they study. That's all I need to do. I'm not necessarily trying to shove it down their throat but just presenting them with a "well, if you love this, here's a thing that you can do which is all that".

An additional element of balance was raised by Susan who noted that while it was valuable for students to hear about scientists and specialists, this should not come at the expense of leaving science open as an option for everyone:

We're also wary of just saying "science: it's done by these specialists". We also have programs and presentations where we want to say "science: you can do it if you like in your back shed". We've got this range of 'here's how you can engage with science' communication messages and experiences to cover the whole spectrum and by providing opportunities for students to ask questions of scientists because that's important as well.

Students acquire skills in science centres which are highly beneficial for their lives after school.

The ability of science centres to foster curiosity, lifelong learning and questioning skills were mentioned extensively by all participants. Alicia's comments cover the major sentiments:

What I want to say applies to museums and other institutions as well as science centres and it's that fostering that lifelong learning or to have curiosity to engage with the world, to not just shut down opportunities and

possible learning experiences because when you leave formal education it's up to you to take control of how you learn, where you learn and when you learn and that doesn't have to be in a formalised setting. Just that lifelong curiosity... Critical thinking skills come into that as well because you'll be drawing upon them for your whole life in making decisions about yourself, your family, things like that.

David noted that science centres help people to identify links and connections from one subject to another, encouraging good thinking skills:

I think just the general thinking skills, encouraging them to explore, to question. We do that in schools trying to do a raft of things more than just the content focus. How do you learn, how do you go about learning how to learn and how can you apply this to other areas. That's something that I think science centres do as well in terms of yeah, here's some content but think about how it works, why it works and make those connections.

Louise recalled a specific science centre program that trained young science students as explainers. She felt that it was invaluable in equipping these students with valuable skills for their future careers:

In my experience, the children who do that [explainer training] are quite good students. They may not be the dux but they are quite good students and often this was a way in which they could enjoy themselves and enjoy science. The kind of skills they are getting...some of them are learning to promote what they love in a confident way. And that's a really good skill to have in any career. I don't think coming in for two or three hours as part of a school excursion is going to give you that but that's for a different audience. But this kind of specific program is going to give them skills which are valuable in just about any career.

Zoe believes that science centres provide an environment that allows people to develop the confidence to try things and be wrong. Alicia and David agreed. Because of the open-ended nature of the experiments, exhibits and experiences in science centres, there is a sense that you can test an idea, have it not work and then figure out why. Being wrong in your initial ideas and attempts in a science centre setting is 'okay'. David believes that this is a better environment for the students who may typically be afraid of trying something for fear of being wrong:

I think science centres are a safer place to be wrong. You can test it by yourself, you can play. In schools you feel more like 'everyone is judging me' there is that culture which is embedded in the system which some people might like but others maybe rather than having a go they just don't try it in case they are wrong whereas in a science centre they're more likely to pick up something and just have a crack....I've taken kids to science centres who are the reluctant ones in the classroom but in the science centre they'll just run and do things.

Zoe agreed with the 'judgemental' nature of school assessment. This lead to the next statement for discussion:

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

Louise picked up the discussion first and vehemently disagreed with the opinions of schools being judgemental and causing students to not want to participate:

Louise: *This is a continual assumption that schools are rigid, schools have content, schools test, children are judged. I come from a personal inquiry background, everything is criterion referenced, the rubrics are all linked to good taxonomy, there is explicit teaching of what to do...knowledge and understanding are usually in the test yes, but the test questions are usually based on the student doing something like commenting on newspaper article and examining their knowledge and understanding in an open ended way. I've been teaching this way for about 12 years, I believe this sort of thing is happening in schools...That's what the formative assessment is all about, it's about breaking down that fear of failure. I believe that a true educational institution – like a school, and probably a science centre, does all of these things all the time and should be doing all of these things all the time. I keep this in my mind when I teach that I am developing the skills for the future and I'm disappointed with some of these questions, with the assumptions being made. I can't remember when I've had children scared of failing, except for when they've come from such a rigid system that has been working that way, and yes there are some around...*

Alicia: *So, Louise can you – wait, (to moderator) can you read the question again? (reads) so Louise, you're saying you think it's false?*

Louise: *I think it's false. If anything students are risk takers – they will write something...*

Alicia: *I'm going to play devil's advocate here. I am a great critical thinker, I have great problem solving skills. I'm a good communicator – I've made my living from all of these. But don't ask me to design the Sydney Harbour Bridge because I wouldn't have the first idea. There are some areas where you do need to just learn the facts, the content.*

Louise: *My argument is, if they're taught well in schools, then if anything this will enhance their performance in certain tests, and this is certainly what things like the*

PISA tests say.

Alicia: *But these things have to happen in parallel is what you're saying, they have to do both.*

Louise: *Absolutely…if they've had practice at communication, if they've had practice at reasoning, then when they're exploring that question - like in PISA - and responding then they should do quite well at that…*

David agreed with the need for interpersonal skills to be "explicitly and implicitly incorporate[d] into the classroom". He comments that he has seen an increase in the level of importance of these skills in terms of helping the students academically:

I think they're very important skills to have, especially in a school environment we probably need do it more often. And those interactions have a positive effect in the classroom and their learning outcomes. If they learn how to interact with others, they can learn better from each other and that helps the learning of, whatever part of the curriculum I'm teaching.

Zoe believes that while science centres can contribute to the development of soft skills, she does not believe it can do so in isolation:

I just wonder how much soft skill teaching you can do in a science centre. Realistically they'll come in to do a two hour workshop or a three hour visit, they'll sit with me for half an hour while I present a show, so there's definitely room for that to occur within a science centre but I don't think a three hour visit is going to pick up the 'slack' that not teaching or developing soft skills in the classroom everyday can do. So I like what you guys (to the teachers) are saying about an integrated approach.

The influence of the type of school was also discussed, for example the difference between a Steiner or Montessori school in comparison to a public or private school. The different educational approaches may have some influence on soft skill development, but this was not regarded as a certainty:

Susan: *Well I can only speak to what I see in the workshops and we can't say 'all of this particular type of school are better at this activity' but I do recall, I can't say if it was Steiner or Montessori but it was definitely one of the 'alternate' education systems, they came in to do a workshop – like a marble run, Rube Goldstein type activity - and they were far and away the most amazing kids in terms of what they achieved in the time. The facilitators were amazed at how quickly the kids got into it, they cooperated, they were problem solving, but that was one.*

Louise: *It is a system with far fewer representatives here so that is still a valid observation.*

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.

There was unanimous agreement amongst all participants that this statement was true. David also mentioned the role of socioeconomic background and the family situation on student skill development in particular.

The importance of other influences continued in discussion of the next statement.

Visiting a science centre has little impact on whether students follow careers in STEM.

Personal interest in a topic was identified as important in determining career choice, but not necessarily the sole determining factor.

Susan: *I think you can't pin down one influence. It's a collaborative effort between teachers, parents, science centres, peers, tv shows…*

Zoe: I think you can still have a love and appreciation of science but I don't think that will necessarily follow through into a career in science. But hopefully, if it doesn't – if you don't end up becoming a scientist then you have a respect for what scientists do or have a sense of wanting to learn about science and be interested in it.

When discussing influences on career choice, Alicia highlighted inspiring teachers as being consistently identified by high achieving scientists as what motivated them to become a scientist.

School excursions were nominated by Louise as a highlight, particularly in the Australian context where excursions may be a very long way from home.

Probably going on excursions. It's a highlight. Don't discount it only being two or three hours of a child's life… it is important to be out of the classroom and making science authentic in some other context and that's what you are doing.

The benefits of science centres in this context were seen by David as "value adding" to everything else that is happening in a school. Susan believes that science centres can share possibilities of some career options rather than creating scientists:

So if you're a kid who is interested in making some social difference for example and you encounter a scientist interview or a story about research that is creating social change that's worth thinking about or checking out or it's something that they might encounter again in a couple of years' time. It's sort of a planting of ideas rather than stop/go, yes or no from this point once you go out the exit door you will be a scientist.

The theme of coming back to a science centre experience or idea – mentally – was explored further in the next statement discussion.

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

All participants feel that the trigger given by a science centre visit to a child is highly dependent upon the adult accompanying them. Louise will use exhibits in science centres to trigger memories and understanding of concepts she is teaching that term or the next term in class. Susan described the difficulties of being able to provide relevant content for all year groups and state and territory syllabi, but emphasised that the role of science centres was to spark interest rather than 'teach' content:

I guess part of the approach that we want to have is that we want people to be sparked to investigate something after they've left. So we don't expect people to walk out with a firm understanding of the speed of light, we're not expecting that content knowledge to be a really high level, but we are hoping that both adults and kids will use an exhibit and say "that's really strange, that reminds me of something I've seen when I've been fly fishing". We do get anecdotal examples, so the polarising light exhibit for example, we had two guys come in who wear their polarised sunglasses when they go fishing on the lake, so when they came in and used the exhibit they were like "oh! okay, so that's kind of how it works – right". So we have that approach of feeding curiosity and making connections but the theoretical knowledge, we appreciate that thirty-second attention span at the exhibit is really hard to garner, so it's not what we're trying to achieve.

Zoe can still recall things she learnt in a science centre when she was nine years old, more than twenty years ago, illustrating the potential for long-term 'impact'. Alicia identified the problem with defining 'impact' in this context, and in her discussion supported Susan's point about making connections between the science centre exhibits and real life:

And that lasting impact, there could be so many ways to interpret that. It might be that they're more likely to go and visit another science centre or a museum of a different kind or it might be that, my daughter banged a wire coat hanger on the kitchen bench yesterday and was talking about sound waves. It could be anything, it might not be something immediately obvious.

Science centres rarely focus on the relationship between science and industry

Susan and Zoe both identified immediate industry links in their science centre – an entire campus dedicated to it as well as a show which had been commissioned by a local organisation. Zoe alluded to the balance that needs to be struck when working with industry in this way.

Zoe: From a performing science shows perspectives, I think we're not explicitly tying things to industry but we do always try to present phenomena, explain phenomena, why is this important to you. I think it's more in our shows explaining why the phenomena is important to them and where they might see it in their everyday life rather than, here's the application of that in a more industrial sense. But we do have one entire show on the [an area] but that's kind of the exception because we were funded to develop that by the [The Area] Authority.

Alicia: does it matter where the funding comes from?

Zoe: *No, no it doesn't matter where the funding comes from but I don't think that that show is the show that we would generally make. For example the other shows we've made or developed recently are deep ocean shows or talks about deep ocean. We talk about the kind of submarines you might use to get to the bottom of the ocean but mostly it's about why it's difficult to explore the bottom of the ocean and so yeah, less about the industry and more about the stuff in there. But because we were funded by them, it's more about them and the industry around the Area and what that authority wants to communicate.*

Louise noted that industry such as BHP and Rio Tinto fund science fairs and school science competitions. She also emphasised the importance of it being a tangible thing for students to see and start considering as a career option:

If it's fun, if it's hands on, if it's at a science centre then you can say how that can be applied to a context but I think at this high school level it's really important because they are starting to think about what they're going to do once they leave school and often ask the teachers 'what's the point of learning this?' so its really important to have those things to make it 'real'.

The application of the science to the industry was another recurring theme in the discussions with Zoe believing that the application of the science is what is most commonly shown in science centres, rather than industry specific exhibits and exhibitions. Alicia recalled seeing that approach in another local, science based institution. Susan observed that the links to industry could be put in the exhibition – very explicitly from the developer's perspective – but the visitor may not pick up on this link unless they are "absolutely interested". David demonstrated this point:

Last time I visited, which was only a few weeks ago, the biggest industry link I can think of is in [the gallery for young children]. Because you've got kids playing with

the cement mixer and the ramp and all that kind of stuff and that's all used in industry which until now is link I hadn't made!

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

This statement caused reflection in all the participants. The consensus appeared to be that the science centres may be limited by their available resourcing and also their original goals and objectives, however they are still part of an integrated solution:

Louise: Societies which really value science and innovation like Singapore and China they are having science centres. So it may not be that the science centres is [sic] contributing but obviously those types of societies see the value of having that as something for the next generation. It may not work the way it's stated there [in the statement] but it's worth investing in these types of things to get students motivated to become future scientists and technologists. In a sense the answer is yes but it's a long view, it's not the short term.

Alicia: so are you saying they don't do enough or they do?

Louise: They don't directly contribute at all, but indirectly they do by motivating students to perhaps consider this as a career or an interest.

The science centre participants acknowledged that it is something which is gathering traction within the field, however Zoe does wonder if this is actually a role that science centres need to shoulder individually:

I think it kind of goes back to what we were talking about before where science centres are kind of being a support for all of these other ways to develop people through family, through teachers, and different areas so maybe science centres aren't doing enough - but is it our job to?

Other trends arising from the discussion

Fun

The emphasis on the fun in a science centre was discussed as a possible detriment to them being considered as a place of education, particularly for school groups coming as part of a longer excursion to the area:

Zoe: I've been told by teachers that [this science centre] is the fun destination, it's the fun place and seen as being the reward for being good the rest of the time. It's the carrot.

Alicia: How nice is that though, being considered the fun place.

Zoe: Yeah but then I wonder if it's being sold as "this is the fun thing you get to do after going through all this educational stuff at all the other centres". Does that then suggest that perhaps it is not intended by those teachers to have a lasting impact it's just supposed to be "yeah, do the slide. Okay, now let's go home"?

The need for soft skills

The overall discussion of soft skill development led to comments from nearly all of the participants regarding the need for the current, and future, scientists to be able to clearly communicate about their work. This extended beyond the scientist to public dialogue, to the need for scientists of different disciplines to be able to work together.

Susan: *With the scientists I've seen in the video conferences and the scientists I've seen at professional conferences, they often talk about being academically brilliant in their field but they have to work with similar researchers or researchers who are academically brilliant in other fields and suddenly they have to communicate this deep well of knowledge to someone who doesn't really know anything about it. So that's quite an important element of having that understanding of your subject but also being able to share it. In the age of big data, when we have all of this information being brought together to try to make connections between phenomena, that's also an important aspect of the job that development of the soft skills.*

Zoe: My sister is a researcher and she sometimes tutors students, as you do working in a university, and that's what she really wants to do. She tutors these students in geology and paleoclimate and stuff and she wants to teach them all how to talk to people about the science that they are doing. She says "oh I talk to so many scientists who just don't know how to speak". Again, sample size of one but it's something that is very important to her to develop.

3.1. Discussion and conclusions

The dominant themes arising from this focus group can be grouped into three main categories:

- The benefit of schools and science centres working together
- The relevance and importance of soft skill development to students as well as current, and future, scientists
- The myriad influences on student skill develop-

ment and career choice.

All participants agreed that science centres have a different purpose and function to schools. However the integration of the two, working in tandem, was consistently identified as a positive, powerful relationship. Teachers were identified as a commonly cited reason for why individuals pursue STEM careers. Science centres were identified by teachers as capable of influencing teaching practice, to make teaching more engaging and inspiring. In this example alone the potential positive impact of this integrated approach is quite apparent.

Schools are focusing on soft skill development throughout the curriculum, particularly interpersonal skills. The teachers participating in this focus group believe that interpersonal skills are vital for students to exceed educationally, and once they are working. All participants agree that these skills are desperately required, and in some cases seriously lacking, in the existing cadre of scientists.

Other skills such as critical thinking and creating curiosity and a desire to embrace lifelong learning were also identified as important contributions made by science centres. Science centres were not necessarily felt to be the main driving mechanism for the development of these skills, so much as one important part of an integrated approach. All participants acknowledged the role of artistic, sporting and other pursuits which contributed to skill development, especially that of the socioeconomic background and the family circumstances. The influence of external sources on student skill development and career choice are many and varied. Participants agree that science centres add value to students, but are not – and possibly should not – be considered a determining factor.

3.2. Advantages of informal learning in science centres and museums

Science centres were considered to be more 'free choice' learning environments. This has multiple advantages as discussed by the participants. First of all, free choice allows students (and visitors generally) to pursue what interests them which is vital to engagement. Science centres also provide an atmosphere that facilitates visitors attempting something without fear of being 'wrong'. Participants felt this helps visitors develop confidence and fosters questioning skills and creativity, necessary ingredients for lifelong learning.

Both schools and science centres are important sources of information about opportunities and pathways for career choices. Science centres in particular show the application of science to everyday life, including the industrial applications. All participants felt that this, more implicit approach was appropriate and suitable for students, with the option of providing 'real context' for students who want or need it. Making the links between different subjects was also considered a strength of science centres by participants, as this helps the development of visitors' thinking skills and their ability to make connections.

Participants also believed that the mutual exchange between teachers and science centres were extremely valuable. For the teachers this meant that the science centre value added to what they were doing in school. Some participants had observed colleagues being inspired by what they had seen in science centres, highlighting the potential for science centres to influence teacher practice. Science centre staff acknowledge the specialist pedagogical knowledge held by teachers, and rely on teacher input to ensure that programs and experiences are appropriate for the target audiences.

Overall, the participants in this focus group conveyed that they felt science centres were vital cogs in a complex chain of influences on student development and career choice. In particular, they believe schools and science centres (in Australia) have a mutually beneficial partnership that enhances student outcomes in both content and soft skill development.

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

One of the greatest challenges for science centres identified by the participants, was also one of the greatest advantages. The fun nature of science centres was seen as integral to fostering engagement. However there were concerns that focusing purely on the 'fun' would relegate a science centre to be considered as non-educational.

The duration of a typical science centre visit was also considered a challenge. Most visits to a science centre are for only a few hours and, especially in the case of students visiting from a different part of the country, exposure to a science centre may not be repeated. In this case, the participants acknowledged the influence of the accompanying adult. Teachers could treat a science centre visit as a fun, possibly non-educational experience. Likewise parents may not engage with their children during the visit, treating the science centre like an area for play rather than learning.

Much of the career and industry discussion revolved around the need for balance. Science centre staff want to emphasise that science is something that anyone can do or enjoy, it is not just something for specialists. But nor do they wish to explicitly push people into STEM careers – something that the other focus group participants agreed was not appropriate.

The other concept of balance was applied to the explicit inclusion of industry in science centre exhibits and programming. Again, a challenge for science centres is also linked to their strength. Science centres have the ability

to highlight the application of science and to make connections between scientific concepts and phenomena and how they apply in the 'real world'; a previously discussed advantage of these institutions. This highlighting however, leads to the implicit coverage of industry links. Should an industry body or group fund an explicit program or exhibit/exhibition this then could cause science centres to yield some of their editorial control, as alluded to by one of the science centre participants in this study.

4. Recommendations

Participants in this focus group believe that the positive impacts of a science centre visit come from recognising the integrated nature of influences on students. Science centres should promote themselves as both fun and educational and assist the accompanying adults to extend the impact of a visit to a science centre. They could do this by encouraging visits to other, similar institutions, discussing the visit and experience further or even encouraging further exploration of phenomena at home. Teachers could embed the science centre visit in the curriculum materials they are covering in class, explicitly linking the 'fun' to the classroom. Many science centres already attempt to facilitate these links and extensions; this is applauded and encouraged.

Science centres were identified as being a positive influence on teachers, and vice versa, through an exchange of ideas and resources. Science centres should actively engage with teachers through the provision of professional development activities, and seek teacher input into their own program design, to ensure that the educational experiences from the formal and the informal are complementing each other and incorporating the best practice from each sector.

The ability to communicate effectively with others outside of your discipline was highlighted as an especially important skill. One participant believed that the explainer-training program offered to science students by the science centre was a classic example of how science centres can contribute directly to this. Perhaps science centres could also offer similar experiences to scientists, either through the formation of partnerships (ie a scientist in residence) or short courses in communication skills by the centre or museum staff science communicators.

2 Belgium – Flanders

Author: Magda Kirsch

EXECUTIVE SUMMARY

Flanders has organised three focus-groups at Technopolis, the main Science Centre in Flanders. The first focus-group, organised as a try-out, revealed that more information about the project and also certain concepts used in the statements was necessary because they were unclear but that the protocol for the focus-group did not pose any problems.

The two first focus-groups consisted mainly of teachers. There were also a primary school principal, two people involved in teacher training, one of whom was also a researcher responsible for science communication and a teacher who had previously worked as a science communicator. The third group consisted mainly of members of the STEM-platform, set up by the Flemish government to attract more students to STEM-programmes. They are independent experts, coming from industry, research and education. Next to these, there were a secondary school principal, a talent coach, a staff member for science communication at a university college and a university researcher present.

Generally speaking the three focus groups held the same opinion about most statements and disagreed or agreed with the same statements. The last focus group was more outspoken whereas the first two focus-groups were more balanced in their opinion. It has to be noted that where the opinions between the three focus groups differed it could be explained by the fact that especially the first focus group thought mainly in terms of Technopolis and that the second and especially the third focus group also considered the Flemish STEM academies and other workshops as science centres. The third focus group regretted that there was not enough focus in the statements on technology.

The three focus groups agreed that science centres can play an important role to catalyse STEM innovation skills although they cannot do this on their own. The main message that was given is the fact that science centres and schools have complementary roles and can each play an important but different part in the enhancement of soft skills for STEM. Especially the fact that science centres have more resources than schools should make it possible for children to experience, enjoy, explore, and be in awe for phenomena they have learned about at school.

Science centres should therefore engage in a constructive dialogue with schools but also other stakeholders such as parents, industry and teacher education institutions in order to know what their needs are. By engaging in such a dialogue science centres can enhance their activities and exhibits and can maximise the impact on the visitors to the science centre or the science museum.

Especially the last focus group stressed that the impact of a science centre will differ enormously according to the kind of science centre we talk about. They regretted that no clear definition was given for science centre and also regretted the absence of the word technology or STEM in most statements.

Most participants pointed out that although children and young people must enjoy a science centre and be able to explore exhibits according to their own interest, the visits to the centre (especially in a school context) should be prepared and there should also be a follow-up of the visit. However, especially in the last focus-group the majority of the participants agreed that the children should just enjoy the science centre.

The last group also stressed that more focus should be given to science centres such as clubs or groups where youngsters meet at a regular basis to work together with others at creative aspects of STEM. Such activities will have much more impact on the acquisition of soft skills than an occasional visit to a science centre.

Moreover most participants thought that visitors should also receive information about scientific and technological or technical careers. The link between science, technology and jobs in industry should also be focused upon more explicitly and children should be able to encounter positive role models. Especially at key moments in their life, children and young people can be impacted upon by the visit to make a choice for or against STEM-studies or STEM-careers. It should be made clear that there is a shortage in industry of scientific, technical and technological graduates at all levels.

Although all participants are convinced that just one visit to a science centre or museum will not be enough to acquire skills for life after school or have an impact on the learning processes of visiting children, they all believe that it can be a step in a learning process or a trigger to develop certain skills. The higher the frequency of the visits, the higher the impact will be and the more children can experiment themselves, the more they will learn in terms of innovative skills. In this respect STEM-academies or workshops enable children with an interest in STEM to develop their passion.

The two last focus groups highlighted the importance of promoting equal opportunities as to the acquisition of soft skills through science and technology centres. On the one hand gifted children with particular interest in STEM should be given regular or repeated opportunities to have on-hands inquiry-based STEM experiences. Similarly special efforts should be made to enable socially disadvantaged children to have access to science centres and to acquire soft skills to enhance their opportunities for study and future life.

All participants agreed that science and technology centres can play an important role in motivating children for STEM. However, especially the group of corporate representatives stressed that more focus should be put on technology. In order to maximise their impact science and technology centres should diversify their activities and also try to enlarge their target audiences.

LIST OF NATIONAL CONTRIBUTORS

FOCUS GROUP 1 (TRY-OUT)

KDH PS 1.:
Female primary school teacher (5th form). Visits Technopolis every year with her pupils. She also organises technology classes for her pupils

MV: PS 2.:
Male primary school teacher (6th form). Visits Technopolis with his pupils on a yearly basis

GB: PS 3.:
Female PE teacher in two primary schools. Has visited the exhibition on the Romans in Technopolis

FV: SST 1.:
Male teacher secondary school teacher. Teaches sciences in the second grade of secondary school. Has visited Technopolis with his children

CA: SST 2.:
Female secondary school teacher. Teaches Technology and Design. Wants to start a STEM-class

SM: SST 3.:
Female secondary school teacher. Teaches in the third grade of the section Mathematics and Sciences. Has volunteered to participate with her students in a try-out of nanotechnology workshops at Technopolis

LL: SST 4.:
Retired secondary school teacher. Male. Used to teach sciences in the third grade of secondary school in the section Maths-Sciences

KDS: SST 5.:
Seconded secondary school teacher. Member of STEM platform

FOCUS GROUP 2

H.B. SST / TT.:
Male secondary school teacher (3rd grade). Teaches Physics. Is also involved in teacher training of the KULeuven.

K.D. PS 4.;
Male primary school principal. Head of group of primary schools. Involved in a pilot project on STEM

E.G. PS 5.:
Female primary school teacher (5th form). Visits Technopolis on a yearly basis

K.K. SST 6.:
Female secondary school IT teacher (third grade). Her school is a STEM school of Excellence. Works as a volunteer for Coderdojo but wants to move these workshops to the school.

K. L. SST 7.:
Female secondary school IT teacher (second grade). Is also involved in Coderdojo. Colleague of K.K. Is involved in interdisciplinary and intergrade project in her school.

M.P. SST 8.:
Female secondary school teacher (1st grade). Teaches general subjects and is also involved in GOK at her school.

D.S. SST 9.:
Female secondary school teacher (3rd grade). Teaches industrial sciences and is also the coordinator for the third grade. Wants to attract more girls to STEM-studies.

D.S. SC 1.:
Male secondary school IT teacher and IT coordinator (1st grade). Used to be a science communicator at Technopolis.

AVDW SST 10.:
Female secondary school teacher. Teaches STEM and is also STEM-coordinator. Her school started a STEM-study programme for the students of the 1st, 3rd and 5th year of secondary school (first year of each grade). Next year the 2nd, 4th and 6th year will follow. They work with intellectual sponsors.

H.V.H. TT/R/SC.:
Female lecturer and researcher at the Artevelde Hogeschool. Is the head promotor of the research centre of the teacher training and coordinator of projects on STEM and sustainability. Wants to develop a research attitude with children. Works together with the science communicators of her Association

FOCUS GROUP 3

P.B. C1.:
Managing Director

VIK vzw.:
Flemish Chamber of Engineers

Memner.:
STEM Platform

E.C. SC2.:
Coordinator Science Communication at Howest, University College

M.D. C2.:
Founder & managing partner TAPASCITY – talent coaching

L.D. C3.:
Director VCL-vzw (organisation for the training and certification of welders), Member STEM Platform

W.D. C4 HFC.:
Operational Development & Improvement Field Operations - CROE - HFC Improvement & Training Telenet NV

M.T. HEM.:
Director marketing & communication Thomas More University College, Member STEM Platform

M.T. C5.:
Senior Vice-president for Telenet Business Telenet NV, President STEM Platform

K.V.D.M. SST 11.:
Project leader SODA[22] – project KTA

L.V.O. R/C.:
Researcher – microbiology , (MICR) at VUB (Free University of Brussels) has started up her own company

C = corporate participant

SC = science communication participant

SST = secondary school participant

PS = primary school participant

TT = teacher trainer

R = researcher

HEM = higher education management

[22] SODA: stiptheid, orde, discipline en attitude – punctuality, order, discipline and (professional) attitude

PROJECT SUPPORT

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1. NATIONAL POLICY ON STEM EDUCATION AND THE ROLE OF INFORMAL LEARNING

1.1. NATIONAL STEM POLICY

Although in Flanders a number of initiatives were taken in the past to enhance STEM, these initiatives were often scattered or only had a limited impact because they were often project based but in 2012 the Flemish Government set up the STEM-action plan that wants to meet the skills needs in STEM through an integral approach.

The action plan was prepared at the request of the Flemish Parliament in order to increase the number of graduates in exact sciences and technology courses. The action plan is a joint project of three policy areas, namely Education and Training, Work and Social Economy and Economy, Science and Innovation. On the grounds of its respective powers, each policy area delivers an important contribution to the action plan.

Apart from an analysis of the shortages of graduates in exact sciences and technology, the action plan also provided a framework for a comprehensive approach to those shortages in the following years. In this, not only the authorities but also education and training partners, schools, teachers, sectoral social partners, enterprises and the media are major players. The action plan is used to better streamline existing and new initiatives and to ensure better access to existing material. Eight themes were chosen to be worked on.

1. Providing attractive STEM education

2. Supporting teachers, trainers and supervisors

3. Improving the educational and career choice process

4. More girls in STEM courses and professions

5. Investing in excellence

6. Adjusting course provision

7. Encouraging sectors, enterprises and knowledge institutions

8. Enhancing the social status of technical professions

The basic principle of the action plan is that scientific institutions, enterprises, sectors and education join forces in strengthening human capital for STEM by providing attractive study and career perspectives. Apart from taking structural top-down measures, bottom up innovative solutions that emerge will be stimulated and supported.

In order to be able to fully implement the action plan a STEM platform has been created that is coordinating the actions of the STEM Action Plan. The STEM platform consists of independent members that have been appointed by the Flemish Government because of their personal expertise in business, higher education, knowledge institutions and the media. That platform is further developing the action plan and concretizing the actions mentioned in it. It also advises the authorities on possible adjustments and the extension of the action plan. Final responsibility for choosing the actions and measures and using resources will lie with the authorities. In order to guarantee responsible decisions a steering committee has been set up with representatives of the policy areas concerned (Education and Training, Work and Social Economy and Economy, Science and Innovation) and of the relevant advisory councils (VLOR[1], SERV[2], VRWI[3]).

22 Flemish Education Council
22 Social and Economic Council for Flanders
23 Flemish Council for Science and Innovation

1.2. NATIONAL AND REGIONAL SCIENCE CENTRES AND MUSEUMS

The main Science Centre in Flanders is Technopolis[26] in Mechelen. Technopolis also coordinates a STEM-academy network[27]. These STEM-academies are regional and local STEM-initiatives where children and young people can enrol for activities during their leisure time on a regular basis. The STEM-academies have voluntarily joined in a STEM-academy network.

Next to these there are also an important number of other science centres and museums such as the Cosmodrome[28] in Genk (formerly Europlanetarium), The astronomical observatory "Mira" in Grimbergen[29], the Brussels Planetarium[30], Hidrodoe[31], the interactive water centre in Herentals, the Museum for Old Techniques (MOT) in Grimbergen[32], the Museum for Natural Sciences in Brussels[33], the National Botanic Gardens in Meise[34], the Zoo in Antwerp[35] and Planckendael (zoo) in Muizen[36], the RVO society in Leuven[37], Explorado in Ostend[38] etc.

1.3. DEFINITION OF TERMS USED

Exhibit: an object or a collection of objects that have been put out in a public space for people to look at: something shown in an exhibition[39]

Exhibition: an event at which objects (such as works of art) are put out in a public space for people to look at: a public show of something[40]

Formal learning[41]: Formal learning is always organised and structured, and has learning objectives. From the learner's standpoint, it is always intentional: i.e. the learner's explicit objective is to gain knowledge, skills and/or competences. Typical examples are learning that takes place within the initial education and training system or workplace training arranged by the employer. One can also speak about formal education and/or training or, more accurately speaking, education and/or training in a formal setting. This definition is rather consensual.

Informal learning[42]: Informal learning is never organised, has no set objective in terms of learning outcomes and is never intentional from the learner's standpoint. Often it is referred to as learning by experience or just as experience. The idea is that the simple fact of existing constantly exposes the individual to learning situations, at work, at home or during leisure time for instance. This definition, with a few exceptions (see Werquin, 2007) also meets with a fair degree of consensus.

Mid-way between the first two, **non-formal learning**[44] is the concept on which there is the least consensus, which is not to say that there is consensus on the other two, simply that the wide variety of approaches in this case makes consensus even more difficult. Nevertheless, for the majority of authors, it seems clear that non-formal learning is rather organised and can have learning objectives. The advantage of the intermediate concept lies in the fact that such learning may occur at the initiative of the individual but also happens as a by-product of more organised activities, whether or not the activities themselves have learning objectives. In some countries, the entire sector of adult learning falls under non-formal learning; in others, most adult learning is formal. Non-formal learning therefore gives some flexibility between formal and informal learning, which must be strictly defined to be operational, by being mutually exclusive, and avoid overlap.

In the context of the present study only informal / non-formal learning in science centres and science museums is focused on.

Soft skills[45]: Soft Skills are behavioural competencies which are broadly applicable both in and outside the workplace. They include proficiencies such as communication skills (being able to communicate), conflict resolution and negotiation, personal effectiveness, creative problem solving, strategic thinking, team building, influencing skills, dependability and conscientiousness, to name a few. They are personal attributes that enhance an individual's interactions, social functioning, job performance and career prospects.

[26] http://www.technopolis.be/eng/index.php?n=0&PHPSESSID=d88637f325079942c536d4a1a6c97e0f
[27] http://stem-academie.be/drupal
[28] http://www.cosmodrome.be/
[29] http://www.mira.be/
[30] http://www.planetarium.be/frontpage.php
[31] http://www.hidrodoe.be/
[32] http://www.mot.be/w/1/index.php/MuseumEn/Museum?language=En
[33] http://www.natuurwetenschappen.be/
[34] http://www.plantentuinmeise.be/PUBLIC/GENERAL/index.php++
[35] http://www.zooantwerpen.be/
[36] http://www.planckendael.be/
[37] http://www.rvo-society.be/
[38] http://www.explorado-oostende.be/
[39] http://www.merriam-webster.com/dictionary/exhibit
[40] http://www.learnersdictionary.com/definition/exhibition
[41] http://www.oecd.org/edu/skills-beyond-school/recognitionofnon-formalandinformallearning-home.htm
[42] Id.
[43] Werquin, P. (2007). Moving Mountains: will qualifications systems promote lifelong learning? European Journal of Education. Volume 42, Issue 4, pages 459–484, December 2007
[44] http://www.oecd.org/edu/skills-beyond-school/recognitionofnon-formalandinformallearning-home.htm
[45] Introductory text Walter Staveloz (see annex 2, Part 1)

Example: the "soft" skills required for a doctor, would be empathy, understanding, active listening and a good bedside manner. The "hard" skills necessary for a doctor would include a vast comprehension of illnesses, the ability to interpret test results and symptoms, and a thorough understanding of anatomy and physiology.

STEM-academies (Flanders) are regional and local STEM-initiatives where children and young people can enrol for activities during their leisure time on a regular basis. These STEM-academies are initiatives that have as an objective to discover and develop passion for STEM and are targeting children and young people up to 18 years old. They are interactive, have a competence component and are dealing with one or several STEM-themes and with some continuity outside school time. Moreover children participate in them on an individual basis.

STEM-academy-network (Flanders): Recently a STEM-academy network has been created. These STEM-academies are regional and local STEM-initiatives where children and young people can enrol for activities during their leisure time. The STEM-academies have voluntarily joined in a STEM-academy network.

STEM-coaches (Flanders): Are external experts who work or have worked in a technical or technological sector in industry and support teachers of the 5th and 6th form of primary schools on a voluntary basis to help them get their pupils acquainted with science, technology, technical skills and mathematics. They are willing to share their passion with teachers and/or a school. They are available for the school at least 3 half days per year. They can support the teachers in their class but also help the school develop a roadmap for the teaching of STEM. As they are external consultants the school will decide on how to implement the advice given.

The participants to the focus groups regretted that no definition was given for science centre. They therefore decided to take into account as well the "traditional" science centres or museums where visitors come for the interactive exhibitions and exhibits as the STEM-academies or science clubs where children come on a voluntary basis to participate in extra-curricular activities.

1.4. LIST OF ABBREVIATIONS

AISL: Advancing Informal Science Learning
ASTC: Association of Science Technology Centers
CERN: Conseil Européen pour la Recherche Nucléaire (European Council for Nuclear Research)
CPD: Continuous Professional Development
IBSE: Inquiry Based Science Education
NGO: Non-governmental organisation
NSF: National Science Foundation
SC: Science Centre
STEM: Science Technology Engineering and Maths
STEAM : Science Technology Engineering Arts (All subjects) and Maths
VET: Vocational Education and Training

2. OUTCOMES OF THE FOCUS GROUPS

2.1. INTRODUCTION

Mrs Rita Dunon, responsible for STEM at the Flemish department of Education and Eric Jacquemyn, CEO of Technopolis welcomed the participants to the focus-groups and thanked them for being present. They also informed them that the discussions in the focus groups are being recorded.

Yves Beernaert, the facilitator of the focus-group then gave a short introduction on the international study: "Catalyzing STEM Innovation Skills in Informal Learning" for which the results of focus-groups in 11 countries or regions will be used. Walter Staveloz of the Association of Science Technology Centers has introduced the action research project an AISL "Innovations in Development" project. Goals are to increase the ability of science centers to facilitate awareness and development of 21st century innovation skills in youth, and to develop, test, and deliver a professional development model that advances practice in this area.

The study focuses on the role museums and science centres can play in supporting STEM-policy and the acquisition of STEM competences. The starting point was the fact that children in countries with a high PISA-ranking (like Flanders and Finland) are not necessarily interested in STEM. However, students who are interested in and motivated for STEM have often been in contact with STEM in out-of-school environments where learning methodologies are more focusing on interdisciplinarity, problem solving, teamwork and flexibility, the so-called "soft skills" that are in demand in business and industry.

Based on the results of the focus-groups in the participating countries the researchers want to investigate three hypotheses: "1) Science centers can be an effective environment for a broad base of young people to acquire innovation skills necessary to participate in the 21st century workforce; 2) Science centers can implement programmatic change to respond to promising practices in this area; and 3) A systematic professional development strategy for science center practitioners and leadership, based in empirical research, is the method by which this can be achieved."

The report of the Flemish focus-groups as well as the summative report of all the countries concerned is financed by the Flemish Ministry of Education and Training.

2.2. THE 11 STATEMENTS

The statements were not sent to the participants in advance. Before starting the discussion, the participants were asked to introduce themselves. They were also informed of the fact that the discussion would be recorded.

One of the participants of the third focus group (C5) points out that the title of the study "Catalyzing STEM Innovation Skills in Informal Learning" should have been clearer and simpler. Mrs. Dunon clarifies the title as "enhancing soft skills in an out-of-school environment". One of the other participants of this focus-group (C1) says that he rather likes the word catalysing as a catalyst increases the chemical reaction but is not consumed.

Thereafter the discussion on the statements is started. They are proposed to the participants as well in Dutch as in English in order to make absolutely sure that the original statements are being discussed. They are discussed and put forward for discussion one by one.

1. We should let children just enjoy science centres, not turn centres into schools.

All participants of the focus-groups agree with this statement. However, one of the participants of the third group (R/I) immediately reacts that she would have liked the statement to go on "and children should enjoy schools as well". She thinks that children should in fact experience the joy of learning. In the first focus-group they stress that when a child is interested in something and enjoys something it learns more and will also want to know more about the subject (PS 1). In the second group they think that a child will not come back if it hasn't had any fun (SST6). Especially in the first focus-group it is stressed that if the experimental exhibits are presented in a way that reminds too much of the school, it might kill the interest and the motivation of the pupils (PS 2). Another participant (C1) thinks that although he thinks children should mainly enjoy the science centre he is convinced that in order to be effective the visit should be prepared and followed-up especially when carried out in a school context. Many schools visit a science centre as a school trip and he thinks it is unacceptable that some teachers sit in a cafeteria while children are visiting the centre. In the three focus-groups several participants agree that it is useful (some think even necessary) to prepare and follow-up the visit especially when carried out in a school context and that the visit should be more than just fun (SC 1). One primary school teacher (PS 1) states that teachers can prepare the visit by giving assignments and let pupils experiment in class to see which experiments are successful and which aren't. Thus the children will be even more interested and attentive during the visits.

However, virtually all the participants think that at the science centre children should be able to choose what they are going to do according to their interest (food, music engineering). In secondary education pupils will often link a guided or prepared visit to a Science centre to evaluations and this can be a factor that hinders their spontaneity (SST 1). Another secondary school teacher thinks that it is important that children discover things by themselves and that they can be amazed by what they discover (SST 7). A project leader working in a secondary school (SST 11) thinks that it must also be possible for children to go to a science centre and just enjoy it. They might then be more open for innovative ideas. The coordinator of science communication at a university college (SC 2) agrees with the latest statement as she thinks that children will have more intrinsic motivation when there is no preparation of the visit at school. It also enables them to focus on the things that really interest them. Also a corporate participant (C5) totally agrees with the statement and thinks that children should just enjoy the centre so that everything is possible and nothing has to be done. Another participant (C4) refers to a birthday party[46] for his daughter that was held at a science centre. It was for her a very nice experience that she still remembers with joy. By mentioning this he draws the attention to the fact that science centres have to develop a variety of activities which may stimulate attention for STEM. Another participant (C3) adds that a visit to a science centre can be like a journey into the unknown and that children should be taken along that voyage to discover things. Afterwards the experience can be used in the classroom. Especially in the first group some teachers think that the spontaneity of children should not be hindered or limited as spontaneity enables them to discover new things (SST 1). Therefore they think that the visit should not resemble a school context. One primary school teacher (PS 1) remarks that she regrets that some of her colleagues think that schools kill spontaneity and she points out that innovative approaches are also possible in the classroom. Another participant thinks that schools can learn from Science centres as far as approaches are concerned as the schools should definitely not kill the motivation and the interest of the children (SST 5). Although most teachers are not in favour of giving children worksheets when visiting a Science Centre, one participant (TT/R/SC) points out that some children actually like worksheets. The same participant also points out that adults are often not aware they are steering children towards certain exhibits they themselves find interesting. Although all participants agree that children should mainly enjoy the science centre one participant (HEM), who has no STEM background, is grateful that there is a wide range of exhibits but also information on the exhibits so that she can answer the "why" questions of her children when visiting the centre in a family context.

[46] Several Flemish science centres (Technopolis, Explorado) organize birthday parties where children combine a visit to the science centre and experimenting with a regular party.

Even if information and learning materials are available and used, the children will still enjoy the centre because the context is different from school.

Most participant teachers think that schools and science centres should be complementary and that what is being offered in science centres should be additional to what is done in schools (PS 4). Schools can learn from science centres especially as far as didactical approaches are concerned and science centres can learn from schools about their target audiences; what the competences of the pupils are, what they are interested in and what the needs of the schools are (PS 4). Moreover when schools have visited a science centre, this experience should be used in the classroom. There should be a real symbiosis between the science centre activities and the school activities.

Several participants (especially of the first two groups) point out that science centres have more resources than schools and that they have the possibility to exhibit and demonstrate phenomena the pupils have learned about at school. Because of these important resources they are very often ahead of what happens in the schools. Schools evolve more slowly (SST 1). Others think that it is more the approach that counts rather than the resources. Especially the primary school teachers point out that innovative learning is also possible with limited resources. One teacher gives the example of two-weekly technology classes in her school (PS 1). She offers enquiry-based learning using cheap materials that children bring from home. Children love it and are very enthusiastic. However, in order to let children experiment and learn from their mistakes, more time must be allowed than the usual 50 minutes. Others indicate that also the resources of science centres can be limited. However, many teachers (especially secondary school teachers) think that active learning is easier in science centres than in the class room. Projects like Robocup and experiments with nanotechnology have an added value for schools even if these activities have not yet been integrated in the curriculum (SST 3). Because of the lack of resources to acquire the latest technological gadgets schools have to rely on Science centres to be able to use state-of-the-art equipment for a class of pupils or visit high tech exhibitions (SST 3). One participant remarks that it is also interesting to bring the science centre to the school (PS 1). She refers to the techno trailer[47] that comes to schools and where children can do all kinds of experiments. However, the techno trailer is only available for pupils in the province of Antwerp (PS 1) but she has managed to find a loophole.

One participant (SST 2) observes that it is clear that the younger the children, the more motivated they are. This means that children should visit Science centres as early as possible but should also be confronted with innovative teaching and learning methods at school. Especially in primary school but also in the first years of secondary school, pupils are very motivated. Therefore her schools wants to set up a STEM-project in the first year of secondary school. They want to raise interest for STEM and let the children experiment and inquire because children will better remember what they have discovered themselves. They also hope to make pupils less afraid of STEM-subjects. Another participant remarks that indeed interest in STEM has more to do with approaches than with resources. Children should be able to experience science hands-on (SST 5). One of the teachers points out that it is not always easy to experiment with a class of 25 (SST 1).

According to several participants Science centres should first of all be experiential and the science communicators in the science centres should enhance the experience. Even if the visit is fairly structured as is the case in Planckendael (Zoo) or at the children's university where the science communicators tell a passionate and fascinating story it can become a genuine experience that children adore (TT/R/SC). The communicators must raise the interest of the children and trigger their motivation. This is in fact the role that Science centres should play according to most participants of the first two groups. To maximise the impact of the visit it is therefore not only important that a visit is prepared and that there is follow-up but it is especially important that the children enjoy the experience. The participants agree that there are many factors that influence the experience such as the approach and the science communicators. When children are amazed, interested and triggered the learning process can start (TT/R/SC). Even children who were not interested before the visit, can be triggered during the visit. Triggering the interest of children should be the main role of Science centres (SC 1).

All participants agree that children should enjoy the science centres and that this is the best way to trigger the motivation and interest of the pupils. The participants of the two first focus-groups conclude the discussion on this statement by repeating that schools and science centres have complementary roles. Science centres should trigger the interest of the pupils and schools should build upon the learning process that has been started in the science centre. In the third group a participant (R/I) points out that school visits to science centres are very important because when visits to science centres only take place in an out of school context a number of children will be excluded from visiting a science centre.

[47] Hypermodern high-tech trailer that visits primary schools and where pupils of the 5th and the 6th year of primary school can discover the secrets of chemistry, can generate green power etc.

2. Science centres work better for boys than for girls.

The participants all totally disagree with this statement. One participant (C1) even thinks that it is bullshit. The participants also regret that the old cliché about boys and girls is put forward (all focus groups). They think that this statement is based on the old cliché that boys are different from girls and that the latter are not interested in and do not have competences for STEM. Most participants (especially women) say that they hate this cliché. They think it is rather a societal issue because society expects girls to make different choices from boys. In the two teacher groups some participants point out that interests of girls and boys for aspects of STEM might differ. In the first group two participants (SST3 & SST5) refers to the findings of the ROSE-study[48] indicating that girls are more interested in the social relevance of science and boys more in technology. Also in the second group someone refers to this difference (TT/R/SC). She thinks that boys are mainly interested in more "explosive" phenomena. When going to a science centre boys and girls might choose different experiments but it is definitely not true that science centres work better for boys than for girls.

Especially the primary school teachers disagree with this statement and they also state that at a young age (kindergarten and primary school), teachers see no difference at all as far as interests of the children are concerned. One teacher (PS 5) gives the example of the Mathematics Olympiads where as many girls as boys from her school participate. She also remarks that interest in STEM has more to do with the talent of the children than with their gender. The principal of a primary school (PS 4) points out that the reactions of society probably lead to stereotypes. When a little girl dresses as Bob the builder and a little boy as a female hero nobody will disapprove. However as they get older their "image" becomes more important and children will conform more to what society expects from them. This image is also strengthened by the toys that children are given, the way we talk to them and the way boys and girls are described in books. It is as if from the age of 12-13 onward girls are no longer allowed to be interested in STEM. This might explain why in secondary schools girls rarely choose STEM-studies. The example is given amongst others of a school that offers a STEM-study programme. Only 4 out of 50 pupils in the first year of secondary school are girls (SST 10). Another teacher gives the example of technology programmes where they see the same phenomenon. Several participants agree that society expects girls to make a different choice and that boys and girls want to comply with the image that is expected of them.

One participant (SST 11) notes that visits to science centres are probably more often proposed to boys than to girls by schools or by people who work with young children. This is confirmed by another participant (C4) who points out that at the opening of the Explorado science centre 80% of the visitors were boys (age 7-8). He was very surprised and wondered what the reason might be as schools in Flanders are all mixed schools. This might have had to do with the theme that was chosen for the opening (football world championship) of this centre.

The participants (especially in the second group) wonder how they could attract more girls to STEM-studies. A teacher trainer/researcher (TT/R/SC) who is also involved in the local STEM-academies points out that when children receive enough motivation, she notices very few differences even at the age of 13-14. In this respect the participants point out that activities in science centres are mainly directed at children under 14. If more real research activities for the age range of 14 to 18-year-olds (e.g. in life sciences or chemistry) could be provided in science centres this might possibly help attracting more girls to STEM-studies. They all agree that science centres should offer a wider range of activities that might interest as well boys as girls but also children over 14. One of the participants (TT/R/SC) thinks that older children should be allowed to do in-depth research and experiments. She refers to what is already possible as far as programming and coding is concerned. She realises that when children are allowed to experiment making shampoos or perfumes or in biotechnology (not following directives) it entails security or health risks but nevertheless she regrets it is not possible for older children to work autonomously and even make mistakes when doing their own research.

One of the participants thinks that the different interest in STEM of girls between primary and secondary schools might also have to do with the importance soft skills have in primary schools. It is generally known, according to this participant that soft skills work better with girls than with boys. Others think it is mainly a question of image and society. However, it is not just a question of knowledge. On the contrary, girls are as good at STEM as boys but they lack confidence and easily think they are not good at something. Girls should therefore be encouraged that they are good in STEM in order to make them more confident. Schools should also offer more choices in STEM programmes so that girls also find something that interests them.

When asked by the facilitator if science museums have to do something to attract more girls, most corporate participants don't think it is necessary. As one participant (C1) states, they just have to avoid confirming the clichés about boys and girls. However, the teachers disagree as they thinks that if we want to attract more girls to STEM programmes, they will have to be triggered and motivated for STEM and he fears that this might not happen in school.

[48] ROSE – Relevance of Science education- is ROSE is an international comparative research project meant to shed light on factors of importance to the learning of science and technology (S&T) – as perceived by the learners. Schreiner C., Sjøberg Svein (2004). *Sowing the Seeds of Rose, Background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education) – a comparative study of students' views of science and science education.* Oslo: Unipub AS

Another participant (C5) thinks that science and technology (why not STEM?) centres have to deal more with the "purpose" of science and technology. They have to focus on what you can do with science and technology rather than focusing purely on science and technology. They have to do this as well for boys as for girls. This is also the case for businesses. If businesses want to survive they must be able to explain their purpose.

One participant (C1) regrets the lack of data for this statement. Although we think that more boys than girls visit science centres we have no data. Another participant (R/C) adds that her gut feeling tells her that in schools the old clichés about boys and girls are still being confirmed but she cannot prove that this is actually the case.

Overall all the participants disagree with the statement that science centres work better for boys than for girls but some agree that girls and boys might be interested in different exhibits.

3. Schools can learn more about teaching science from science centres than the other way round.

Most participants disagree with this statement. In all three groups they think that there must be interaction and feedback between schools and science centres and that the starting point must be that they can learn from each other. Two participants (C1 & C5) even start by saying that the statement is wrongly formulated. C1 adds that learning is not about being better than but about interaction and learning from each other. Science centres and schools should not act as competitors but should work together in order to enhance STEM education (SST 1).

They are both compatible and complementary. Only if one assumes that schools are still teaching in a very classical, old-fashioned way then it would be true that schools can learn more from science centres rather than the other way around (SST 6). However, in Flanders most schools have adopted new teaching approaches where teaching is linked to real life. If we do not connect learning to real life experiences the knowledge will not last.

The approach in the schools and science centres is different because they also have a different mission, different objectives and their priorities are different. The mission of the science centres is mainly to trigger the motivation and the interest of the pupils. In science centres the pupils can also experiment in a "safe" environment where errors are not sanctioned as no evaluations take place. The mission of schools is much more comprehensive than that of science centres. They have to transfer knowledge, assess and not only focus on specific aspects like STEM but also on ecology etc. If they want to be able to do the latter they have to work together with science centres. At the science centre the teachers can pick up new ideas and learn new approaches but they can also give feedback to the science centre on how to improve their exhibits and activities (SST 1). Not only science teachers but also teachers of other subjects can be involved in these activities. Several participants (in all three focus-groups) point out that this collaboration and interaction already exists.

One participant (HEM) gives the example of teachers coming to Technopolis to give but also receive information. Another (SC 2) adds that learning materials to be used by schools are being developed by sciences centres. These were presented at a learning-materials fair where Technopolis had a stand and where these materials were also discussed. Technopolis acted as a catalyst and presented learning materials for teachers that had been developed by several science and technology centres. Maybe not all science and technology centres have to develop learning materials but it is certainly an excellent example of cross-fertilisation between schools and science and technology centres (HEM). Also the STEM academies for teachers play an important role as this is an occasions where teachers think about and discuss the attractive methodologies to teach STEM so that there is more impact (C1 and HEM). Another one (R/C) adds that it would be ideal if this collaboration were so intense that education and science centres are articulated and could be linked up. She gives the example of laws in physics that are learned in the classroom without ever seeing the implementation or practice. It would be really nice if children learned these laws at school and saw the implementation at the science centre. In fact in order to learn about science and technology, children need schools and science and technology centres. Therefore it is also important that science centres have excellent science communicators who know their target audiences as the approach (and the knowledge) must be different when dealing with primary school children or young adults (SC1). They must also be able to tell a fascinating story as otherwise the visit could have the opposite effect (TT/R/SC).

Although the collaboration between science centres and schools already exists it could still be enhanced. One of the participant teachers (SST3) refers to an exhibit that she had seen at Technopolis and that she wanted to recreate in her school. She received all the information asked for but also gave feedback on how the experiment could be recreated with cheaper materials. This kind of interaction should be generalised. Science centres could also lend materials or expensive equipment to schools such (e.g. a catalyst). Science centres could also make their labs or equipment exclusively available for a class or a number of classes. In the Netherlands there are regional science centres where teachers can go and use the materials and equipment e.g. in the framework of a project.

Some teachers also point out that especially primary school teachers don't feel at ease when they have to teach science and technology because they have had no or not enough specific training for these subjects. Contrary to secondary education teachers they are no real subject teachers. In this respect it could be said that schools cannot learn so much from science centres but that those teachers who are not happy teaching science and technology can learn from them. There science centres can play a role.

There are also important differences to be noted as well as far as teachers as schools are concerned. On the one hand the most motivated and interested teachers will attend personal development courses but on the other hand the policy of the school and its principal can also have an impact (PS 2). The policy of a school principal can mitigate the differences between the teachers. Teachers should also be able to use different didactical approaches and learn to teach in a student-centred way so that students or pupils can learn from their own experiences. It is also important to make the link with real life experiences. When young people learn to work with Excel sheets and formulas it is important to point out that they are the basis for the programmes and apps they use (SST 6). Another participant regrets that sometimes the approach of schools is too abstract. This is sometimes the case for technical subjects as schools have less resources to acquire the latest technology (SST 2). There science centres can play a role. On the other hand teachers should also try to find the right balance between teaching abstract and concrete subject content

Another participant remarks (TT/R/SC) that a distinction should be made between students in STEM-oriented programmes for whom chemical or molecular models are important and those in other programmes. She refers in this respect to the concept of "Science for all" that is being promoted in Europe. For students in non-STEM programmes the link between chemistry and its applications could be shown using concrete examples like the production of shampoo, perfume or detergents. Although not all children need to study STEM subjects in higher education all children must be taught to think as critical citizens. Also as far as extra-curricular activities are concerned we need not force children to attend STEM-activities but they must all be able to think critically and make correct choices.

Some teachers of the first focus group also think that teacher education institutions don't do enough to prepare the teachers for the new teaching approaches. There is a shift from classical (frontal teaching) towards coaching and guiding students in their learning processes (SST 5). Several teachers think that future teachers have not received the tools to help them act efficiently in that changing role of facilitator who coaches and helps students to work autonomously and assess their own learning. Especially in VET-education teachers already act as facilitators as students cannot acquire practical skills if they are not given the opportunity to practice and learn from their own experiences (SST 2). Another participant notes that science centres should not only collaborate with STEM-teachers but also with other subject teachers as STEM-competences are important for all subjects (SST 5).

The discussion is closed in all three focus-groups by the participants stating that they disagree with the statement. Schools and science centres should learn from each other but they must also reflect on how to make science centres more effective.

4. Science centres should not promote science careers - that's not their job

On this item the participants in the three focus groups have slightly divided opinions. Whereas most teachers consider that "promoting" science careers is not the job of the science centres all participants in the third group agree with one of the participants (R/C) who immediately reacts that she thinks that on the contrary it is the job of science centres to promote science careers. However, although some teachers hate the word "promote[49]" and one (SST 6) even thinks that it might have the opposite effect, because children don't like to be pushed, most of them think that science centres should inform visitors about a wide range of studies and careers in science and technology. Not only purely scientific careers should be focused upon but the broad spectrum of scientific and technical or technological careers. Students (but also primary school pupils) should know which careers and jobs are possible with STEM. They must realise that science and technology is not only for nerds (SS 3).

Especially in the third focus-group the participants stress that science centres should not only focus on the fact that science is fun but especially on what you can do with science. C5 adds that she prefers STEM because science is too limited and that at least technology should be added. Another one (C1) says that he would even have liked STEAM[50].

49 In Dutch the word is associated to pushing someone to do something or advertising a product
50 Science Technology Engineering Liberal Arts and Mathematics (in some cases the A stands for All other disciplines)

When asked how science and technology centres can promote STEM careers C5 says that they should mainly inspire young people by showing examples of how science and technology can be used and focus on the purpose. Because it is difficult to focus on future jobs or careers – as we do not know yet what the future careers will be – it would be easier to focus on STEM studies and show what the challenges of the future are and how STEM can help to face those challenges and what one can achieve by working with STEM. C3 also thinks that the word "career" is not well chosen and that "challenges" would be better to attract young people and show them how interesting STEM can be. When asked by the facilitator whether salaries in STEM careers could be a way to attract more people to STEM studies, the participants disagree because young people should choose their studies because of interest and motivation not because of what they might be paid. Salaries might drop depending on the (over)supply of those graduates and it would be wrong to make promises that could not be honoured (C5). Moreover it does not work as is shown by the example of the shortage of welders although for years it has been said that they are well paid. Lastly it has to be added that when we talk about STEM we are talking about different profiles in industry and also different salaries and not all jobs in STEM are that well paid (C3). This participant also stresses that when we speak of STEM we should clearly focus on all science and technology jobs at all levels starting from those focused upon in VET schools.

Also in the first focus-group one participant (SS5) states that the information should focus on all possible jobs in STEM. She points out that there are STEM careers that children do not know or have not heard of. One participant (SS5) states that science centres should not only target STEM students. In fact they should distinguish between 4 Beta-mentalities[51]:

1) A first group of students who are explicitly interested in STEM;

2) A second group who are not interested at all in STEM;

3) A group that is not intrinsically interested in STEM but interested in a STEM career (the so called career betas)

4) A group of students who could be motivated for STEM because they are people-oriented generalists.

Especially as far as the two latter groups are concerned the science centre could play a role by triggering their interest and motivation for STEM. The information given should be comprehensive also including information on technical and technological or lesser known jobs and also targeting parents.

Another participant thinks that the main role of the science centres is to enhance and promote scientific literacy for all so that we could get rid of the existing clichés about women and technology or about technology only being for nerds (SST 3). One participant thinks that by triggering interest in sciences and technology, science centres might also raise interest in scientific careers. She thinks that children could also be more interested in science careers if on Science Day they were invited to participate in the activities of a science lab or do a traineeship in a zoo. Thus the interest in science careers might be raised and there could be a direct interaction between interested young people and science centres (TT/R/SC).

The group concludes that, although it is not the task of the science centre to promote scientific careers, they should give ample information on such careers. This information should be targeting different target audiences.

According to another participant (TT/SS), science centres should mainly show what scientists do because many young people who study sciences at university have no idea what the everyday job of a scientist is. Students should be informed so that they can make informed choices. He gave the example of a visit to IMEC[52] with last year secondary school students. The students found this visit where they could meet scientists at work more interesting than making experiments in a university lab. Thus the students could see that scientists are not boring, can be passionate about their job and are definitely not working on their own in their lab.

The two first focus groups partly agree with the statement and conclude by saying that although science centres do not have to promote science careers they have to give information about a wide range of careers in science and technology. One participant even thinks that science centres should give personal information to interested students. The participants of the third focus group conclude by saying that they disagree with the statement and think science centre should promote science careers or inform about the challenges that scientist, technologists and technicians will have to face in the future.

5. Science centres rarely focus on the relationship between science and industry

Just as for the previous statement the opinions on this statement are divided between the three focus groups. Whereas most participants in the first focus group agree with this statement, the participants of the second and the third focus group think it depends on the kind of science centre.

[51] http://www.betamentality.nl/?pid=4&page=Carri%E8re%20B%E8ta%27s

[52] Interuniversity MicroElectronics Center

Most participants in the first focus group agree that although science centres rarely focus on the relationship between science and industry they should do so. Science centres should focus on what graduates can do in industry when they have finished scientific or technical studies. This is especially important for older students (SST 5). According to the participants in this focus group science centres should inform and motivate the visitors. They refer to the previous statement where they also recommended informing the visitors on a wide range of jobs in industry. One of the participants points out that young children don't see the link between the experiments they carry out and the applications in industry (PS 1). Another participant thinks this is not necessary and children should mainly be triggered. One of the other participants thinks that it could be the role of the science centre to inform the parents because they do see the link (SST 5). A secondary school teacher (SST 2) refers in this respect to the Port centre (Havencentrum)[53] near Antwerp where there are big billboards with the list of the jobs in the harbour. Science centres could also put such billboards in place.

One participant (SST 3) thinks that the interest in industrial practices also depends on the age of the students and the study-programme they have chosen. Thus, she visited the BASF-centre[54] in Antwerp with last year secondary school students who attend a specialised chemistry programme. These students were very interested in the centre as they had the necessary background to understand everything. Some participants think that one should also avoid over-exciting and overwhelming children with too much information. When children are also given information about the industry and careers it might be too much for them to process all this information (SST 3). It could therefore be better to make it possible for visitors to look up information on STEM-studies, careers and jobs in the industry on computers. Thus it is also possible to target different audiences. Another participant states that science centres should consider what their main mission is. According to her, children want first of all to get acquainted with innovative practices and experiments that are not possible in the school.

In the second focus group one of the participants starts by saying that it depends on what kind of science centre it is. However, even when sponsored by industry or by industrial sectors, there might be some rooms dedicated to the industry or sector concerned but the link with industry is seldom explicit. Most participants agree that the link with industry should not be reduced to sponsoring but should focus on jobs in industry.

Although they think that it is not always easy, they think that science and technology centres should show the link between science and technology and what you can do with it in industry. Some point out that this is already the case in certain centres. In Technopolis there is an exhibition room (Xplora)[55] where children can take up several roles, jobs, functions in industry and see whether they like it through a number of interactive exhibits around jobs that are innovative or capture their imagination. Thus they can see clearly what the link is between scientific and technological studies and the job and career possibilities. Another participant (TT/SST) refers to a visit to the CERN[56] where his students did not only meet scientists but also technicians who work there and who are very proud of what they have achieved. One of the other participants concludes that once again schools and science centres are complementary. It is important that in science centres children or young people get acquainted with role models and that these are being confirmed in the schools.

In the third focus group one of the participants (SST 11) also pointed out that some science centres do focus on the industry and that it depends on the kind of science centre. He is convinced that it does happen in the STEM academies as they are working together with industry. However, not all science centres focus on industry. This is confirmed by C5 who regrets once again that no clear definition of science centre was given. Another participant (C1) would have liked the statement to be: "science centres should focus on the relationship between science and industry" because he thinks that a science centre has on the one hand a didactical duty to explain science and on the other hand the duty to explain the purpose of science and technology and thus make the link with industry clear. Especially the link with the real world must be made. Also here reference is made to the Xplora exhibit at Technopolis (HEM). This department of the science centre has been co-financed by different industrial sectors. One participant (C5) states that all the science centres she has visited have a clear link with industry. R/C thinks that this is less the case when we visit a science museum, a zoo or a botanic garden. Several participants react by saying that the latter are not pure STEM[57].

Although in te first group the participants agree with the statement, they think that science centres should inform about jobs in industry. The participants of the other two focus groups conclude by saying that most science centres focus on the relationship between science and industry but that it depends on the kind of science centre. They think that science centres should offer role models and focus on the purpose of science and technology

[53] Havencentrum : http://www.provincieantwerpen.be/aanbod/dwep/havencentrum/havencentrum.html
[54] http://www.basf.com/be
[55] http://www.technopolis.be/nl/fiche/zones-6-hoofdzones/xplora
[56] the European Council for Nuclear Research
[57] In Flanders a distinction is made between pure STEM and on the other hand soft and care STEM. The former concerns engineering, industrial sciences, biotechnology etc. The latter concerns health care. By soft STEM those studies that include some STEM (like archeology) are meant. The STEM platform only deals with pure STEM.

6. Students acquire skills in science centres which are highly beneficial for their lives after school.

Especially in the first focus group the reactions to this statement are mixed. Some participants of this group think that it depends on the policy of the school whether students will acquire skills at the science centre (SST 5). The visit must be integrated in the teaching approach of the school. Some also think that skills that are beneficial for life after school are age-related.

Several participants in this group point out that it is only possible to acquire skills when the visit to the science centre is prepared and a framework for the visit is provided. This can be done at school but also by the parents (SST 2). One participant (PS 1) gives the example of her school where on the one hand a framework for the visit is given but where on the other hand the visits are also prepared by carrying out certain experiments at school and by paying particular attention to what the pupils actually like. Thus the visit to the science centre can be important for the study-choice after primary school. In this respect one could even say that they acquire skills for life after the primary school or for some children even after kindergarten. In her school technology classes are taught from kindergarten onwards. It is the policy of the school to shift to other than classical teaching approaches and the teachers try to implement this policy.

Another teacher thinks that for some non-STEM students in secondary education programmes like Arts etc., the main role of a science centre is to trigger the interest for science and technology and make a link with subjects like Chemistry and Physics. These students should just enjoy scientific and technological experiences and not so much acquire competences (SST 3).

When the facilitator asks which skills can be acquired at a science centre one of the participants (SST 2) refers to an exhibition about the Romans where pupils acquired knowledge about the Romans for their history class but also acquired technical skills for their technology class especially as far as building bridges and other architectural constructions are concerned. In this respect the visit contributes to assimilating the subject matter of the curriculum in a different way.

All the participants agree that pupils cannot acquire competences or skills if there is no framework for the visit as one cannot acquire competences in one day. If we want the pupils to acquire skills it cannot be a "one shot" (SST 5).

Another participant (PS 1) points out the enormous advantage of the techno-trailer (kind of mobile mini science centre) that comes to primary schools. Schools can reduce costs and children can be motivated for science and technology by carrying out experiments such as making hair gel, working with robots, building bridges etc. just like in an ordinary science centre.

If sciences centres want to focus on the acquisition of soft skills such as problem solving they have to develop a roadmap in collaboration with schools. At the science centre pupils can apply these skills and competences while teachers can observe them. However, the roadmap is only the first step in acquiring these skills and competences. The process must go on as well at the science centre as at school or at home.

Not only pupils but also teachers can enhance their skills and competences. Teachers can transfer what they have learned at the science centre to their pupils (SST 5).

In the second focus group one of the participants starts by saying that in a science centre pupils can be triggered or motivated but that they do not acquire competences. Another one adds that acquiring skills and competences requires time and that one cannot acquire them by just one single visit. Acquiring skills and competences is a process and as was already mentioned in the first group the visit to the science centre can be a step that stimulates acquiring these competences. One participant (TT/R/SC) points out that when we are talking about STEM academies or regular workshops pupils can acquire soft skills and competences because the experience is long-lasting or repeated. Another participant (SST 6) remarks that in that case it is no longer informal but rather non-formal learning as the learners have the intention to learn but the context is informal.

A primary school principal (PS 4) states that he would like to change the word "after" in "in" as he thinks that some soft skills like problem-solving and cooperative learning are stimulated at the science centre and thus they reinforce what children learn at school. Primary school teachers often observe this effect when debriefing or getting feedback from the children after a visit to a science centre. What children have learned in theory at school is enhanced and reinforced by the experience at the science centre. Especially for less privileged children a visit to a science centre can make the difference because very often they are not stimulated at home (TT/R/SC).

One of the main advantages of a science centre is the fact that science communicators can better explain complicated phenomena to pupils or students than scientists in their laboratory. The latter have not learned to communicate at the level of primary or secondary school children.

In the third group one of the participants (C3) starts by quoting a Latin phrase: "non scholae sed vitae discere opportet" indicating that everything we learn in whatever circumstances has to be beneficial for life rather than for school. Another reacts (C1) by saying that he thinks that what students learn in science centres is rather limited

and that he is not convinced at all that they might acquire soft skills in science centres. Once again several participants react that it depends on the kind of science centre we are talking about. If we consider the STEM academies or initiatives such as Coderdojo[58] or other science clubs it is obvious that students can acquire the soft skills that they need for life after school. In the Coderdojo the volunteers work around a project (project-based learning) and they try to develop with the children team-building skills, problem-solving skills but also communication and presentation skills (C5). SST adds that he thinks that all science centres try to focus on soft skills but a visit to a science centre is just one step in acquiring these skills because acquiring skills takes time. It would be too simple to say that just by visiting a science centre for a couple of hours students acquire these skills. SC 2 points out that indeed it all depends on the definition of science centres. If we include initiatives where collaborative workshops are organised for children then we can say that children do acquire soft skills actively. She gives the example of the children's university where students from initial teacher training give workshops and where not only the children involved but also the future teachers acquire soft skills. At the same time future teachers are made aware of how important science and technology are in primary education and they learn how to motivate and interest children for STEM. C4 adds that the soft skills that are acquired by children can also differ from centre to centre or in different contexts and that they might acquire team building skills in one centre and communication skills in another context. The fact that children can experiment by themselves without being judged or without copying what others do will also help develop certain innovative skills such as problem solving or being able to work independently (R/C).

Especially in the two first groups participants stress the fact that a visit to a science centre is only one step in the process of acquiring competences. Most participants conclude by saying that children can acquire skills for life after school in a science centre but that it depends on the kind of science centre whether and what skills are acquired. If the activities take place on a regular basis then children will acquire skills. Otherwise these skills will have to be further developed at school or in another context.

7. Most science centres don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society

The three focus-groups generally disagree with the statement as they think that science centres do a lot in the way of promoting creativity.

In the first focus group examples are given of exhibits in science centres that enhance creativity such as causing chain reactions with different materials (PS 1). However, one of the other participants (SST 5) regrets that there are too few exhibits in Technopolis that allow children to experiment by themselves. A roadmap has to be followed and children cannot decide to change the ingredients of an experiment (such as making super slime) in order to see the effect. Children should learn by trial and error. Although most participants agree they also realise that this is often not practically feasible. In this respect one participant (SST 1) points out that in order to let children learn by trial and error a one to one approach is necessary. This is not possible at the science centre. However, through close collaboration between the science centre and the school the process could be started at the science centre and continued at the school.

On the other hand one of the participants (PS 2) refers to the materials that are on the website of Technopolis (and also of some other science centres) and that can be downloaded for free. This means that there are many more activities possible than those that can be experienced at the science centre and that the creativity of the children can also be stimulated using these materials (PS 1). There are also workshops for older children where they can let their creativity run free (SST 2). One of the participants points out that one of the problems that Flemish science teachers encounter when they download materials from the Internet is that these materials are often in English. Although it could be overcome by working in an interdisciplinary approach with the English teacher, this is not always possible. The advantage of the materials on the website of Technopolis is that they are in Dutch.

In order to contribute to the knowledge society science centres should focus more on reaching all teachers, and share with them what is available (SST 5). They should also target parents and grandparents so that the materials that are available can be disseminated and shared even better.

[58] CoderDojo is a global network of free, volunteer-led, independent, community based programming clubs for young people. These young people, between 7 and 17, learn how to code, develop websites, apps, programs, games and explore technology. - See more at: https://coderdojo.com/about/#sthash.GK7pJieX.dpuf

The participants also disagree with the statement that science centres don't do enough to promote innovation. The example is given of the workshops on nanotechnology. The students can start their activities at the science centre and continue their work at school (SST 3).

In the second focus group one of the participants (TT/R/SC) starts by saying that there is a lot of creativity at the science centres but that this creativity is not enough stimulated. Another one (SST 6) points out that over the last 10 years science centres have made enormous efforts to promote creativity. A primary school teacher (PS 5) gives the example of a visit to the European Space Centre where children have themselves made a rocket, something that definitely stimulated their creativity. Not only science centres but also science museums have made enormous efforts to promote creativity by giving assignments so that children can carry out experiments autonomously. Although this might not be true for all science centres and museums it is true for most of them and therefore several participants think that this is an outdated statement.

However, one of the participants (TT/R/SC) thinks that still more could be done especially to promote innovation and to make the link with innovation in industry clear. One of the other participants (TT/SST) warns not to give too rosy a presentation of higher education STEM studies as this could lead to young people being disappointed. Especially in the bachelor years STEM studies can be very classical and exacting and a number of innovative minds often leave higher education STEM studies whereas they might find their liking in innovative industries. That's why students have to be made aware that science can be fun but is not always fun. One of the primary school teachers (PS 5) agrees and states that we have to teach children that learning does not always have to be awesome and fantastic and that sometimes they have to acquire skills and competences in a classical manner.

In the third focus group one of the participants states that she totally disagrees with the statement because she thinks that no science or technology centre can survive nowadays if it does not promote creativity and innovation (C5). Although one of the participants thinks some science centres do not do enough (SST 11), most participants disagree with the statement. When asked how science and technology can promote creativity and innovation. According to several participants (C1, C5, C4) CoderDojo workshops definitely contribute to promoting creativity by letting children try to find solutions themselves, by not following a fixed roadmap, by experimenting and by being open to all possible solutions. Also in more traditional science centres like Technopolis it is a lot easier for children to be creative than at school because there are no learning objectives and no deadlines (C5). She points out that also in business and industry people become much more creative when there are no fixed deadlines and when everything is possible and nothing has to be done. HEM confirms that although schools have a lot of flexibility and can differentiate their teaching, the learning objectives and deadlines are a kind of straightjacket hampering the creativity of teachers and children. R/C points out that one of the characteristics of innovation and experimenting is that when trying to find innovative ways one fails regularly. However, schools do not allow children to fail. That is why children can be more creative and innovative in a science centre.

When the facilitator asks whether the participants think that children cannot be creative or innovative at school the participants react by saying that the statement does not mention schools (C1) and that it does not mean that schools cannot be innovative or creative but that the creativity of children is mitigated by the pressure to perform. In schools children must learn at more or less the same pace whereas in a science centre they can experiment at their own pace (SC 2). One of the participants (SST 11) points out that it also has to do with the audiences visiting a science centre. They are mostly motivated and interested and even schools visiting a science centre will do so with the classes that are motivated. This already gives a head start to science centres regarding creativity. At the same time he regrets that not all children have the opportunity to visit a science centre. Some participants are surprised to hear this but SC 2 confirms that certain children never go to a science centre in a family context and therefore they have a number of assigned places in their workshops that are given to disadvantaged children. Her university college tries to reach the latter via NGO's working with less privileged or disadvantaged families. Also some CoderDojos are organised in collaboration with a non-profit organisation that is working in disadvantaged areas of Brussels (C5). Especially children of unemployed parents are difficult to reach and more efforts have to be made to reach those children (C5). STT 11 totally agrees.

C3 once again regrets that only science centre is used in the statements and that the word technology (or STEM centre) is lacking. She stresses that it is only possible to be creative and innovative if one already has certain skills. Moreover the word science centre sounds more exclusive than science and technology centre. Therefore it would have been better to use science and technology centres or STEM-centres in the statements. C2 wonders whether teachers in primary schools are talented enough to accompany these creative and innovative processes. In fact teachers want to be helped and guided to introduce those processes. Especially middle aged teachers want to be coached to be able to introduce new methodologies and new approaches. Young teachers at the beginning of their teaching career are far less interested because they want to teach in a more rigid and structured framework as often they find it difficult to organise the activities in their classroom. They want to go back to basics. Another participant (C3) regrets that this seems to imply that inquiry-based and experience-based learning leads

to chaos and this is definitely not the case. However, this is the impression that lives with teachers but also in teacher training and teachers wonder how they can adapt their teaching practice (C2). C3 responds that in order to implement real inquiry-based learning a very detailed roadmap has to be developed containing several scenarios taking into account all possible solutions.

Most participants of the three focus groups disagree with the statement that science centres don't do enough to promote creativity and innovation. However, some think that more could be done to stimulate creativity and that definitely more can be done to contribute to the knowledge society.

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.

In the first focus group the participants find it obvious that one can reach soft skills via other extracurricular activities and one participant (PS2) points out that this is even possible at school on the condition that the school abandons traditional or frontal teaching. Some even think that this statement is irrelevant. In fact one can acquire soft skills like teambuilding in any context where several people try to reach one common goal through cooperative activities. Children have to realise that there are several ways to reach an objective or to find a solution for a problem and that they have to listen to the opinion of their peers to understand different ways of thinking (PS1). This is the case for group sports but also for arts appreciation. Depending on the interest of the pupils they will acquire these soft skills more easily either when practicing sports, when visiting a science centres or for some 'nerds' when participating in a technological project (SST 3). The line of approach will be different depending not only on the interest but also the talents of the pupils (SST 2).

However, one of the participants thinks that a technological project pre-eminently offers opportunities to acquire soft skills as one needs a wide range of skills to achieve such a project (also within the school) (SST 5). Depending on their interest, children can play a different role within the team and thus they can be complementary in the collaboration (PS 1 and SST 3). The condition is that the teacher is prepared to let the pupils work autonomously and give up traditional teaching. In fact especially in primary schools it is necessary to abandon traditional teaching as children have different interests, different competences and also different levels (PS 2).

Although there are special learning pathways for these pupils it remains complicated and labour-intensive (PS3). One teacher points out that it is also the case in certain classes of secondary schools (SST 2).

Also the participants of the second focus group find it obvious that one can acquire these soft skills in other contexts. One of the participants (SST 6) even thinks that it is easier to acquire those skills via sports as there children of all walks of life, origin or even IQ come together whereas at school (especially secondary schools) children of the same age and with the same interests are together in one class. The mission of a sports club is also more open than that of a science centre. Soft skills like team work and conflict resolution definitely feature in sports clubs.

Some participants think that it is wrong to compartmentalise the acquisition of skills and that skills can be acquired everywhere. As the acquisition of skills is a process some can be acquired in one context and others in another context. Thus, one can learn to work together in sports but not practice scientific communication. However, one does not always exclude the other as also in sciences team work is important. We should indeed abandon the old cliché of the lonely scientist working alone in his lab. Nowadays scientific knowledge is gathered and new theories are created by collaboration between scientists and by critical debate on certain phenomena (TT/SST). In STEM all soft skills are important and creativity is possible as well in abstract ideas as in concrete applications. According to this participant this is not possible in sports.

Another participant (TT/R/SC) points out that soft skills such as problem solving and teamwork that have been acquired in a certain context (e.g. sports), can be used and will probably be strengthened in another context (arts or sciences). Thus, students can acquire a wide range of soft skills and when using these soft skills in different contexts they will become more and more skilled. Creativity can be acquired as well in arts as in a science lab (Fablabs)[59]. According to interest, talent or competences, the context can differ. Some will acquire more skills in a science centre, others in sports etc. One participant states that even in sports technical competences can be acquired (SST 8).

Also in the third group all participants agree with this statement. One of the participants (C5) points out that some children who are attracted to STEM might not be attracted to sports or scouting. These children will not acquire those soft skills via other extracurricular activities but they can acquire them via activities in STEM-academies etc. where they can also learn to work with others and where they can do it with passion. That is why such activities are necessary. This does not

[59] Fabrication lab where pupils and students can work creatively in a high-tech environment http://www.mvovlaanderen.be/kenniscentrum/praktijkvoorbeeld/fablab-hoogtechnologie-binnen-handbereik/s/informatica-diensten-bedrijven/t/competetentieontwikkeling/i/praktijkvoorbeelden/

mean that all children who like to go to a science centre or a STEM-academy do not like sports or scouting as some children can acquire soft skills in a wide range of extracurricular contexts (C4). However, for some children it is a real blessing that they can go to CoderDojo or a STEM-academy where soft skills are focused upon because there they can really develop their passion and skills together with others (C5). On the other hand it is good when children can develop different skills in different circumstances: thus they can develop their presentation and communication skills in a CoderDojo and a real team spirit in football etc. (C4). Because of their interest in STEM only some children might become isolated and for these children it is important that they can share their interest with other children who have the same interest and thus acquire essential soft skills (C3). One of the other participants (R/C) points out that not all extracurricular activities help developing soft skills. She tells that as a child she learned to play an instrument but that this did not give her the social skills she needed.

The participants of all the focus groups agree with this statement. They even think that competences acquired in one context can strengthen competences acquired in another context. However, they all point out that it depends on the interest and the talent of the children where they will acquire most competences.

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 centres can play a role.

In the first focus group most participants find this a strange statement. Nobody agrees with this statement entirely. On the contrary they think that by focusing on soft skills children will learn better and the test results might also improve. One of the participants thinks that although she is convinced that the test results will not lower when teachers focus on soft skills, science centres can play a complementary role. She gives as an example the synthetic and analytic skills that one needs to solve mathematical problems. In a science centre pupils can acquire or refine these skills by learning how to programme small robots (SST 2).

Several participants wonder what is meant by "tested skills"[60]. They think this refers to "cognitive skills" because in technical education also skills and attitudes are tested. The facilitator refers to the Anglo-Saxon concept of "teaching to the test".

One of the participants (SST 5) totally disagrees with the statement as she is convinced that by focusing on soft skills the children will better remember what they have been taught (SST 5). Another participant (SST 1) points out that too many teachers still focus too much on facts and figures as they fear that by focusing on skills pupils and students will learn less and that knowledge will be lost whereas it is clear that one can also acquire knowledge in a less traditional way. SST 5 agrees and states that especially in the long term pupils will remember more because they have processed what they have learned. Maybe less subject matter will be covered but pupils will know better what they have learned. She thinks that in this case "Less is definitely more". She adds that in our education system more focus should be put on why pupils have to learn something. If pupils understand the purpose of what they learn they will probably be more open to the subject matter. Too many teachers still focus too much on the amount of subject matter to be covered and too little on the why and the how it has to be taught. She also points out that if we change our way of teaching we also have to change our way of assessing. A shift has to take place from product to process evaluation as the latter is more important for the learning process of the children.

PS 2 remarks that this is already the case in primary education where not only knowledge is assessed but also skills and attitudes. He adds that it is not always easy and that it is particularly difficult to communicate this to parents. SST 5 agrees and remarks that science centres could be involved to show the difference between product and process assessment. This is only possible if the parents actually participate in the activities of the children. They could watch during workshops not only what their children try to achieve but also how they do it.

A primary school teacher (PS 1) points out that focusing on as well knowledge as soft skills does take more time. This can be a problem because all learning objectives must be reached. However, according to one of the participants (SST 5), most teachers are more focused on handbooks than they are on the curriculum or on learning objectives. It is virtually impossible to cover all subject matter in a handbook in one year but it is possible to reach the teaching and learning objectives definitely if schools collaborate with science centres. Teachers should get away from the handbooks and have more confidence in their own professionalism. Also when focusing on soft skills the role of the teacher remains very important. He/she will have to guide and coach the pupils in their learning process (SST 5).

[60] In Flanders there are no national tests. Schools are autonomous and can design their own tests. They only have to prove that they reach the national learning objectives

By focusing on soft skills education becomes more efficient and thus time is saved in the long term (PS 2). This needs a shift in the mind-set of the teachers. Although this shift in mind-set is common practice in kindergarten it is far less the case in secondary education (SST 5). Most participants also think that initial teacher education does not focus enough on the changing role of the teacher and also most professional development courses for teachers focus too little on this changing role (PS 2). Very often teachers are given ready-to-use modules or materials but the CPD[61] courses should also let teachers work more autonomously and draw on their own creativity. Also teachers have to develop their soft skills and more attention should be given to lifelong learning (SST 5).

The creativity of teachers is also sometimes limited by the fixed structures in schools. Young teachers with innovative and creative ideas cannot always put them into practice in their school. Therefore schools and initial teacher education institutions should increasingly work together so that innovative ideas can better permeate the education system (SST 5). This participant also thinks that science centres must work harder to attract new target audiences such as parents, initial teacher education institutions and organise workshops for teachers in primary and secondary education. At the moment especially interested teachers will visit science centres or attend their workshops. Professional development courses should aim at reaching more teachers. A primary school teacher (PS 1) points out that this has practical and financial consequences for the schools. Even as an interested teacher one cannot attend all CPD courses one would like to because one needs the permission of the principal of the school.

In that respect one of the other participants (PS 2) regrets that only interested and motivated teachers who are willing to collaborate with science centres to develop a true STEM policy are present in this focus group. However, these teachers might in turn try to convince their colleagues (SST 3). A primary school teacher (PS 1) suggests that during the pedagogical seminars at school[62] science centres could try to attract more teachers by coming to the school and giving information on what they do.

One of the ways to attract more teachers is by informing them about the scientific studies that have proven that by focusing on soft skills learning can be enhanced. Students remember better what they have experienced or implemented themselves (SST 3). However, teachers must be aware that in order to get better results they must not only adapt their teaching but also their assessment (SST 5).

One of the other teachers (PS 2) thinks that it will probably take several decades to convince all teachers of the fact that there are more innovative approaches to teach and that not all children have the same learning style.

The participants of this focus group conclude that they disagree with the statement as acquiring soft skills is very important in order to make learning effective. Pupils can acquire these soft skills as well at school as at the science centre but the collaboration between these two is very important.

One of the participants of the second focus group (PS 5) points out that especially in primary schools a lot of attention is already given to soft skills such as working in team, self-reliance, dependability, perseverance, accuracy etc. Children are assessed on these soft skills and must also show that they become more skilled using them and also learn to learn better. It is obvious that one must start teaching soft skills from a very young age onwards and that learning pathways must be developed for these skills so that the learning can continue in secondary education. This teacher totally disagrees with the statement and she thinks that on the contrary by focusing on soft skills test results will get better.

Although nobody totally agrees with the statement several participants (especially secondary school teachers) believe that focusing on soft skills and letting children experiment, finding out results by themselves and discussing them does take more time than traditional teaching. This means that there is less time left for the transfer of knowledge. However, they do believe that children will remember better what they have learned through experiments, personal experience and debate. Moreover one of the participants (SST 7) points out that in order to have a serious debate one needs a solid theoretical knowledge. This means that knowledge and soft skills go hand in hand.

Some participants disagree with the statement as they think that less time would be lost in the class context by collaborating with science centres. But this implies that the time in the science centre to apply what one has learned at school would have to be spent outside class hours. In this respect there is no unanimity in this focus-group.

[61] Fabrication lab where pupils and students can work creatively in a high-tech environment http://www.mvovlaanderen.be/kenniscentrum/praktijkvoorbeeld/fablab-hoogtechnologie-binnen-handbereik/s/informatica-diensten-bedrijven/t/competetentieontwikkeling/i/praktijkvoorbeelden/

[62] In Flanders there are no national tests. Schools are autonomous and can design their own tests. They only have to prove that they reach the national learning objectives

Most participants of the third focus group totally disagree with this statement. However, one of the participants (C1) thinks that it depends on whether schools have the soft and the hard skills in their learning objectives. He points out that both soft and hard skills have to be taught, otherwise children will not acquire the skills they need for life after school. They need both and it is not a question of either or. HEM regrets that an outdated statement is being discussed because studies have shown that both knowledge and soft skills have to be integrated in the competences students need. C5 states that when she recruits new employees she judges them 50% on talent and 50% on attitudes. The project leader of SODA[63] (SST 11) who is working at a VET school tells the other participants that this is the reason why they started 5 years ago with the SODA project in his school. Although the students had the necessary hard skills, they could not find or keep a job because they lacked soft skills. The students who meet the requirements of the SODA project are rewarded at the end of the year by getting a SODA certificate and a place on a list of privileged (SODA) students that is given to their possible employers in partner companies. They have noticed that focusing on these soft skills does not take any time away from the hard skills and that on the contrary it is easier to teach them. Moreover students have scored better on all tested skills. Since they have started the project some 30 other schools have introduced the SODA project. One of the other participants (C 2) asks what the validity of the project is. As the project is quite recent the long-term validity has not been proven yet (SST 11). C2 finds it arbitrary as talented students who do not have the SODA skills tested will not be on the list of the SODA students although they might be the most innovative. He also wonders what the scientific value is. STT 11 responds that the project is scientifically supported by Prof. Valcke of the Department of Educational Studies of Ghent University. It was especially developed for VET schools where students often lack the soft skills they need to find a job. C1 concludes by saying that virtually all the participants disagree with the statement and that they think it is false on the condition that soft and hard skills are taught in an integrated manner.

10. Visiting a science centre has little impact on whether students follow careers in STEM.

Some participants of the first focus group disagree with the statement because they think that the visit to a science centre can be a trigger to choose for a career in STEM. Others think it is just one of the factors that can influence students to choose a career in STEM. SST 5 indicates that choosing a career in STEM is much more complex than being triggered by a visit to a science centre. She thinks that science centres should offer information on a wide range of careers. It also depends on the framework that has been provided for the visit. SST 3 points out that it also depends on the social context because the study or career choice of children is often determined by the parents and some don't want their children to go for a career in STEM.

Some parents cannot help their children in making the correct career choice or are not interested in the studies or the careers of their children. That is where schools must play their role (PS 1). That is also why science centres should develop a target audience policy and reach out not only to students and teachers but also to parents (SST 5). She even suggests that a statement about target audiences should be added to be discussed.

It is clear that choosing a career is not a question of "either or" but of a combination of factors. The impact of a visit to a science centre on the career choice of pupils will never be very important, especially not when it is just one single visit. Such a visit might have an impact on students who doubt about their career choice but economic factors might influence students more. For many students statistics about employment (like the shortage of engineers) might have a bigger impact than a visit to a science centre (SST 1).

In the second focus group one of the participants (TT/SST) starts by saying that he thinks that such a visit can have an influence on the career choice of students but that this can also be negative. He gives an example of a visit to the CERN where one of his students decided not to study Physics after a discussion with one of the researchers. Young people who have to make study or career choices can easily be influenced. They need a role model. Therefore it might depend on who they meet at the science centre whether they choose for or against a career in STEM. Therefore it is necessary to bring children to the science centre at a young age and as frequently as possible so that the choice does not depend on one negative experience. The younger and the more frequently children visit science centres, the greater (and hopefully the more positive) their choice will be.

Some participants think there is little impact unless they visit the centre at a key moment in their life. A primary school principal (PS 4) gives the example of a visit of pupils of the last year of primary school to an Experilab[64]. These children were positively influenced by the visit and several pupils will probably choose a technical study programme in secondary education.

In the third focus group opinions are divided. C1 thinks that regrettably this is still the case as we still do not have enough students who choose STEM-careers. R/C notes that the visit to a science centre can have a positive impact on the choice of students for STEM-careers on the condition that it is a positive experience. C5 points

[63] SODA: stiptheid, orde, discipline en attitude – punctuality, order, discipline and (professional) attitude

[64] Mobile laboratory

out that because CoderDojo is a recent experiment in Flanders it is difficult to assess its impact but that she is convinced that when children visit a STEM-academy regularly it should have a positive impact on the choice of students for a STEM-career. Several participants agree that the frequency of the visits is important. C4 remarks that although there must be a certain frequency, this frequency must not be too high either because then it might become a burden as most children still have other hobbies or interests. The facilitator asks whether role models can help. C3 points out that coaches in STEM-academies or CoderDojos can be an inspiring role model for children to choose for a STEM-career but she does not believe that just one visit to a science centre will have an impact on the choice of students for STEM-careers.

In all focus groups the participants more or less agree with the statement. However they point out that when the visit takes place at a key moment in the life of the student or when the visits take place on a regular basis the impact of the visit might be more important. They also state that the impact can be negative depending on which role models they meet at the science centre.

11. Science centres do trigger the attention of children, but do not invest in learning processes with real long term impact

Most participants of the first focus group agree with the statement and think that science centres do trigger the attention of children but that contrary to schools, science centres do not and cannot invest in long-term learning processes as most pupils will only visit the science centre once. One of the teachers present (SST 1) states that also in this respect the partnership between schools and science centres is important and should be further developed. Another one (PS 1) confirms and points out that science centres can make a contribution to long-term processes by offering teaching materials to support teachers. As far as long-term learning processes are concerned, the focus of the science centres should be on the teachers as teachers should accompany pupils in their long-term learning processes, not the science centres (SST 5).

The science centre is in fact an expertise centre where teachers can come along to pick up ideas (PS 2). Workshops for teachers can be organised and teachers can gather new ideas e.g. on Inquiry Based Science Education and the Nature of Science rather than just receive ready-to-use learning materials. Science centres must focus on learning processes in science and in technology rather than on facts and on transfer of knowledge (SST 5).

One of the teachers (PS 2) thinks it is all too non-committal. For the moment only interested and motivated teachers come to the CPD courses at science centres. He thinks that it is difficult to motivate all the teachers and that very often only a small group of teachers within a school works on innovative approaches. Even during the compulsory pedagogical seminars the involvement of some teachers is quite questionable. Therefore there must be more focus on learning communities within the school or on peer teaching (SST 5). This should be stimulated by the principals or other people responsible for the school rather than be imposed. In primary schools this is not obvious as principals do not have assistants and must in some cases still teach. In fact each school should have someone to motivate teachers and coordinate all activities around STEM (PS 2). The collaboration between teachers also depends on the culture of the school (SST 5).

A secondary school teachers suggests that science centres could bring together interested teachers from all corners of the country. The latter could then share and exchange interesting or good practices (SST 1). SST 3 agrees and suggests it would be good if teachers who feel isolated at school could come together and feel supported. The science centres could also focus on good or interesting practices and inform about them (SST 5). The same participant thinks that STEM could be a catalyst when discussing interdisciplinary teaching as it already brings together four disciplines. Especially in secondary education teaching is still too much compartmentalised and no links are made between the different subjects. PS 2 points out that indeed teachers in primary education teach all subjects and that they can easily interlink different disciplines but that it is all the more complex and also makes it daunting for some teachers who lack confidence. However, within a school teachers who feel more confident teaching certain subjects could support their less confident colleagues. When a number of congenial teachers are collaborating and the pupils are enthusiastic the other teachers might follow. This implies of course that the principal of the school allows this kind of collaboration.

The participants conclude by saying that science centres can't accompany students in their long-term learning processes but they can invest in the coaching of teachers and they can also stimulate the collaboration between teachers.

Also in the second focus group most participants agree that it is difficult for science centres to invest in long-term learning processes of the students. This is the job of the teachers. However, science centres can have an impact on the teachers and thus indirectly on the long-term learning processes of the students.

However, one of the participants (TT/R/SC) thinks that science centres can have an impact on the long-term learning processes of the children as the latter can be triggered by what they have experienced at the science centre and start doing research by themselves. It is also obvious that STEM academies or other similar initiatives can have an impact on the long-term learning processes of the children as they concern interested children who meet regularly and carry out experiments together.

Also this focus group refers to the fact that some science centres also organise seminars or courses for teachers and thus they have indirectly an impact on the long-term learning processes of the pupils. One of the missions of science centres is the professional development of teachers. During these professional development courses there is often a focus on inquiry-based or experience-based science education. The participants agree that pupils will remember better what they have learned when they have been taught in an inquiry-based or experience-based manner. They point out that it is not always necessary to go to a science centre to experience inquiry based science education but that this is also possible in the classroom. Not only science centres but also industry invests in this kind of professional development for teachers. This is very much appreciated by the teachers as it allows them to learn about and get acquainted with innovations in industry.

The teacher trainers present don't think it is necessary to bring their students in initial teacher education to science centres as on the one hand (TT/R/SC) they have their own science communication centre that collaborates with labs for children and with the STEM academies where the future teachers can practice and on the other hand (TT/SST) because the students already have a Master's degree in sciences. One (TT/SST) points out that especially primary school teachers should attend CPD at science centres so that they are better prepared to teach sciences in their class. The other one (TT/R/SC) thinks that even more attention should be given to collaboration between initial teacher education and industry. She also thinks it is important for future teachers to learn how to teach sciences informally.

In the third focus group the participants once again remark that their agreement or disagreement with the statement depends on the definition of a science centre. When talking about a once upon a time visit to a science centre it is probably true that the science centres do not invest in the long-term learning processes but not when talking about regular visits (SST 11). C1 points out that several science centres like Technopolis invest in the learning processes of children indirectly as they invest in workshops and professional development of teachers or future teachers. A science centre is not a replacement of a school and learning processes with real long-term impact are still acquired at school (C5). However, it once again depends on the frequency of the visits and on the definition of a science centre (SC) and on the mission of a science centre (C2). Science centres do not have to take over the mission of a school (C2).

In the three focus groups the participants agree with the statement that (traditional) science centres do not invest directly in the long-term learning processes of the pupils. However, they all point out that science centres do invest in the long-term processes of the teachers indirectly through CPD courses for the teachers, by bringing interested teachers together or by making learning materials available for the teachers. In the second and third focus group participants pointed out that when the concept of science centres is enlarged to STEM academies or similar initiatives, they have to disagree with the statement.

2.3. CONCLUSIONS OR REMARKS OF THE PARTICIPANTS AT THE END OF THE FOCUS GROUP

All participants are asked to give their final conclusions or additional remarks:

- Science centres should not only see children or pupils as their target audience but also teachers and principals. They have to work towards different target audiences and also diversify their activities. Their mission could include helping schools to develop a STEM-policy. Schools should also focus on more than one objective (e.g. being an ecological school) but try to diversify their objectives. As far as inquiry-based science education is concerned teachers should be aware that a lot of experiments are possible with cheap materials. For experiments with more expensive materials or sophisticated equipment schools can turn to a science centre (PS 1).

-Inquiry-based STEM education should not be seen as something new or something additional but just another way of teaching. Also in other subjects this enquiry-based teaching approach could be integrated. Science centres could help to introduce new teaching approaches. Feedback between schools, teachers and science centres is very important. This feedback and interaction should not only be about ready-to-use teaching modules or worksheets but mainly about learning processes. There should also be interaction with networks of teachers (SST 5).

- Pedagooogia[65] 3000 points out that the pedagogy for the third millennium should be inclusive and should cover all subjects. SST 3 wonders whether we should focus on STEM or on all subjects (STEAM). If the latter were the case then it would be possible to have collaboration between language and science or other subject teachers who are eager to use new didactical approaches. She also wonders whether initial teacher education institutions should only focus on STEM or on new pedagogical/didactical approaches.

[65] http://www.pedagooogia3000.info/

It is clear that science centres can play an important role in disseminating enquiry-based teaching. Science centres should also enhance their collaboration with universities and university colleges in general and with teacher education in particular (SST 3).

- Science centres should promote online working even more as this is easier to organise than a visit to the centre (SST 4).

- Teachers should be able to try out new teaching approaches or experiments in a "safe" environment where they can make mistakes. This could be the role of a science centre. Science centres should also set up a platform for STEM teachers where any teacher can ask practical questions and share information via a chatroom. According to this teacher the existing KlasCement[66] platform is on the one hand too gigantic and on the other hand too limited (SST2).

- One of the participants (SST 7) states that we should not assume that all children visit a science centre with their parents. Quite a number of children never get that opportunity. Therefore the science centres should reach out to less privileged children and families.

- This is confirmed by one of the other participants (SST 6) who points out that many science centres and STEM initiatives are only known by the middle classes or by parents who have a degree. She thinks that the best way to reach children of less privileged or disadvantaged families is through the school. We must therefore bring the science centres or STEM initiatives to the school or visit the science centre in a school context.

- A science communicator (TT/R/SC) also thinks that we should invest more to reach less privileged children via STEM-academies or other similar initiatives. She adds that some parents can only be reached through community workers or NGO's working in less privileged neighbourhoods.

- Another participant points out that government and the administration have recently focused a lot on STEM but the definitions of STEM vary enormously. He would like to know the definition that the Flemish government gives to STEM. Mrs. Dunon explains that the reason why the Flemish government focuses on STEM is the fact that there is an acute shortage of STEM graduates at all levels in industry: we need as well bachelors, masters as technicians (especially girls). Therefore the definition of STEM-studies in Flanders refers to pure or hard STEM study programmes and it does not include soft STEM or health care STEM. Because it is difficult to influence the study or career choices of young people the policy-makers want to stimulate passion for STEM. Thus they hope that more young people will choose STEM studies.

- One of the participants also points out that science centres still focus too much on children under 14. They should invest more in the age group of 14 to 18 year olds (TT/SST).

- A science communicator (SC 1) responds that the science centres are aware that this is the case. They are working out a policy and are investing in more activities for older students. The workshops on nanotechnology are an example of this new policy.

- R/C would like to know more about the eventual action research project by ASTC and the real purpose of the focus-groups and how the outcomes are used. They would also like to see concrete examples (like Coderdojo or STEM-academies) given in the report as this would improve the understanding of the reactions on the statements.

- C1 concludes that he would like to see the focus of the science centres on how to attract more people to STEM-careers. Science centres can definitely be a trigger and create a greater affinity with STEM. He would also like to see an inventory and description of the existing science and technology centres and the activities they offer or organise (professional development, workshops etc.). He would also like to see a kind of typology made with clusters (zoological gardens, botanical gardens, technology centres etc.)

- C3 states that she thinks that the focus is too much on science (which sounds a bit elitist) and not on technology. She would like to see science and technology centres focus more on technical and technological skills that are needed for a lot of jobs in engineering and technology.

- STT 11 points out that in English the word science sounds less elitist than in Dutch. He would also like to see more focus on technological and technical jobs. In fact it should be made clear that when we talk about jobs or careers in science and technology all qualification levels are concerned. C1 adds that it would be good to focus more on craftsmanship.

- SC 2 thinks that it is good that there is such a wide range of science centres because it enables children to choose from a wide range of possibilities and that there is a centre for everyone. The wide variety of centres is for her an added value. Moreover she thinks that science centres should be embedded in the local society. Children who live far away might visit a prestigious science centre like Technopolis once but in order to enhance the impact local STEM academies, children's universities etc. are necessary.

- C4 is convinced that more children should visit science centres and probably the best way to bring them to the science centres is via the school. It could be the role of the STEM-coaches to encourage schools to visit science

[66] KlasCement is an educational portal site of the Flemish Ministry of Education and Training. On the website learning materials can be shared. http://www.klascement.be/

centres. He has recently started working as a STEM-coach in a school and is still wondering how the offer of the STEM-coach can be adapted to different age levels.

- C2 points out that it would be nice if there were a kind of synergy between STEM-coaches and science centres to spot STEM talents as he loathes the word "soft skills" because soft skills have nothing to do with talent. It is not because someone has certain skills that he/she also has talent. STEM coaches could try to detect these STEM talents and science centres could develop programmes for those children. This also means that validated tools should be developed to discover these STEM talents.

3. CONCLUSIONS

3.1. CONCLUSIONS PER STATEMENT (FOR THE 3 FOCUS-GROUPS)

1. The participants all agree that children should enjoy science centres and that teachers or parents should let them explore and experience by themselves. However, most of them think that a visit to a science centre should be more than just fun especially when visits are carried out in a school context. In a school context the visits to the science centre should be prepared and there should also be a feed-back or follow-up to maximise the impact. On the spot children should be able to explore, to investigate and also make mistakes. Although most participants think that the visit should not resemble too much the school context, some point out that if the science communicators of the science centres bring a passionate story the context can be quite structured and even children who were not motivated before the visit might be triggered by it. The participants conclude by saying that the main role of the science centres should be to let children experience and explore science and trigger their enthusiasm and motivation for science. Science centres should work in symbiosis with schools.

2. Nobody agrees that science centres work better for boys than for girls. Especially at a young age (kindergarten and primary school), teachers see no difference at all. Nevertheless they point out that especially in secondary schools the scientific interest of boys is different from that of girls and girls rarely choose STEM-studies. Several participants agree that society expects girls to make a different choice and that boys and girls want to comply with the image that is expected of them. They wonder how more girls could be attracted to STEM-studies. In this respect they point out that activities in science centres are mainly directed at children under 14. If more real research activities for the age range of 14 to 18-year-olds (e.g. in life sciences or chemistry) could be provided in science centres this might possibly help attracting more girls to STEM-studies.

3. The participants don't agree that schools can learn more about teaching science from science centres than the other way round. They stress there should be interaction between schools and science centres and that they can learn from each other. Both have a different mission and different approaches with the science centres focusing on experience and practice and the schools on knowledge. In order to enhance this collaboration feedback and interaction between the two are very important. Science centres should know the needs of the schools and schools should know what is available at science centres. The participants also point out that nowadays not only science centres but also schools try to link science to everyday life. The participants conclude the discussion on this item by saying that schools and science centres have complementary roles and that they should reflect together on how to enhance science centres and motivation for science and technology.

4. Some teachers present during the focus groups agree that science centres should not "promote" science careers because this could have the opposite effect. However, most think that it is their role to inform children about and motivate them for science careers. By motivating children for science more children could choose a scientific career. Some participants think that it is the role of a science centre to show what scientist do and to provide role models thus showing how passionate scientists and technicians can be about their work. Especially people from business and industry think it is the role of a science and technology centre to motivate young children for jobs and careers in science and technology at all qualification levels by showing them what the purpose of science and technology is.

5. Most participant teachers agree that Science centres rarely explicitly focus on the relationship between science and industry. Even in science centres sponsored by industry the link is not always obvious. However, the corporate participants think that most science centres do focus on this relationship. The participants (of all the focus groups) agree that there should be a link, especially to jobs in industry. In a certain way this is already the case as in some science centres children can experience what they are good at. According to most participants science centres should focus even more on the link between science and what one can do (purpose) with scientific but also technical studies in industry at all levels thus impacting on the studies young people choose. Once again the participants think that schools and science centres have complementary roles.

6. The participants have divided opinions on whether students acquire skills in science centres which are highly beneficial for their lives after school. Most participants think that just one visit to a science centre will not have an impact on the soft skills or competences of young children as acquiring skills is a long process. However the visit might be a step in acquiring these skills for life

after school. Most participants think that it depends on the kind of science centre or activity whether we acquire skills. If there is a certain frequency as in the STEM-academies or when it is a workshop of several days or in clubs where children meet on a regular basis, they can acquire skills and competences that are highly beneficial for life after school. Especially for children from less privileged families this can be an opportunity to acquire skills that are not nurtured at home.

7. Opinions are somewhat divided on this statement. Most participants disagree with the statement and think that science centres do enough in the way of promoting creativity, innovation and in contributing to a knowledge society and some even think that no science centre can survive nowadays unless it promotes creativity and innovation. However, some participants think that science centres don't do enough especially as far as innovation and the knowledge society are concerned. They point out that as far as innovation and the knowledge society are concerned there is still way for improvement especially as far as the link to industry is concerned. It can, however, depend on the kind of science centre or science activity. Especially clubs or workshops will enable children to become more creative and innovative. All the teachers agree that over the last ten years there has been a tremendous change in the approach of science centres and museums as far as promoting creativity is concerned. Therefore some think that this statement is outdated.

8. All the participants find it obvious that the soft skills that one aims to achieve are important, but that these can also be reached via other (extracurricular) activities like sports, arts appreciation, scouting etc. Some think that sports are an even better way to acquire these soft skills as children from all ways of life, culture and interest meet there. Several participants point out that soft skills can be acquired in any context and that it is impossible to compartmentalise them. Others point out that certain skills such as teamwork can be acquired more easily in a certain context whereas communicating in a scientific way can only be acquired in a scientific context. Several participants stress that teamwork is nowadays not only important in sports but also in scientific teams. They all agree that competences acquired in one context will be strengthened when used in another context. Thus, children can also acquire a wide range of soft skills. Some children will acquire these soft skills more easily in sports whereas for others STEM workshops will be the place where they achieve them.

9. None of the participants completely agrees with the statement that focusing on the soft skills in schools will lower the results in test scores by taking time away from tested skills. Most agree that focusing on soft skills will even enhance test results. Especially primary school and lower secondary school teachers but also a VET school teacher point out that not only knowledge but also soft skills are assessed and that learning pathways are developed for these soft skills. There are, however, slight differences in opinion between these teachers and those of the last years of general secondary schools. Although the latter are also convinced of the importance of soft skills, they find that sometimes they lack time to devote to soft skills and that there science centres can play a complementary role. The corporate participants think that when soft and hard skills are taught in an integrated way it will have a positive impact on test results and therefore they disagree with the statement.

10. Most participants think that visiting a science centre can have an impact on whether students follow careers in STEM. However, this impact can also be negative if the students meet the wrong role models. Most of them agree that generally a visit to a science centre has little impact on the choice of students for a STEM career unless this visit takes place when they are at a key moment in their lives like going to secondary or higher education. At that moment students might choose for a STEM-career if the experience is positive. Also more frequent visits to science centres or STEM-workshops can have an impact. It is therefore important to see to it that the students meet the right role models or have a positive experience.

11. Most participants agree with the statement as they are convinced that "traditional" science centres do trigger the attention of children, but cannot invest in learning processes with real long term impact. They also think that it is impossible for science centres to invest in long-term processes unless pupils visit them on a regular basis. However, that is why STEM-academies or similar initiatives do invest in long-term learning processes. The participants also agree that science centres can indirectly have an impact on the learning processes of pupils through the teachers. They think that teachers might be triggered by what they see in the science centre and adapt their teaching practices. Science centres can (and do) also offer professional development courses for teachers and learning materials and thus indirectly have an impact on the long-term learning processes of the pupils.

The overall conclusion of the focus groups is that science centres should mainly trigger the attention and motivation of children for STEM but that the impact of the visit to a science centre can be enhanced by a close collaboration with schools and by integrating the visit in a structured framework offered by the school. Thus there can be an impact on the long-term processes, on acquiring innovative skills and possibly also on the choice of careers. They all stress that if the visit is just a "one shot" the impact of the visit on the soft skills of the children will be minimal or nil but that when children attend a STEM-academy or STEM-workshop in a science centre on a regular basis the impact will be much more important.

However to maximise the impact, science centres should not only focus on students but also on teachers, industry and other stakeholders. Only by collaborating with all the stakeholders will the science centres be able to fully play their role.

3.2. CONCLUSIONS ON THE ROLE OF SCIENCE CENTRES IN THE ACQUISITION OF SOFT SKILLS

As the primary objective of the study is to find out in how far science centres can enhance the acquisition of soft skills and as in some of the statements the focus was not so much on soft skills, these conclusions summarise the ideas of the participants on the acquisition of soft skills in science or technology centres.

As mentioned above it is very important to define what is meant by a science centre. Acquiring soft skills is a lengthy process that requires time and one cannot expect young people to acquire these skills just by one single visit to a science centre.

If we see science/technology centres and museums just as centres that are visited for the day then most participants agree that what the science centres can do as far the acquisition of soft skills is concerned is rather limited. The visit might just trigger or stimulate soft skills such as creativity, problem solving, communication skills, team-work etc. If the science centres want these visits to be effective they have to develop a roadmap or pathway in collaboration with schools. Thus the visit can be one step in the acquisition of soft skills because acquiring skills takes time. In order to further develop these soft skills the learning process must go on as well at school as at home or in other extra-curricular contexts. That is why one of the participants wants to change the statement about acquiring skills for life after school into "life in school" as he thinks that some soft skills like problem-solving and cooperative learning are stimulated at the science centre and thus reinforce what children learn at school.

However, if we include SC initiatives where collaborative workshops are organised for children then we can say that children do acquire soft skills actively. If we consider initiatives such as the STEM academies, Coderdojo or other regular STEM-workshops or clubs to be science/technology centres then it is obvious that students can acquire soft skills and competences because the experience is long-lasting or repeated and in most cases focuses on soft skills such as problem solving, creativity, team-work etc. Although most participants agree that these soft skills can also be acquired in many other contexts some are convinced that for instance working on a technological project pre-eminently offers opportunities to acquire soft skills as one needs a wide range of skills to achieve such a project. Others think that depending on the interest and the talents of the children they will acquire these soft skills more easily either when practicing sports, when visiting a science centres or for others when participating in a technological project. Soft skills such as problem solving and teamwork that have been acquired in a certain context can be used and will probably be strengthened in another context.

Although most participants agree that by focusing on soft skills in schools, children will learn better and the test results might also improve, science centres can play a complementary role especially as far as problem solving and creative skills are concerned as pupils can experiment in a "safe" environment where they can fail.

Therefore several participants stress the importance of collaboration between science centres and schools in the acquisition of soft skills. They point out that not all children have the opportunity to visit a science centre or to attend a science/technology club in a family context but all children have to go to school. Especially for less privileged children a visit to a science centre or attending other STEM activities could make the difference because very often they are not stimulated at home. Visits to science centres could be organised in a school context or mobile science centres could come to schools. Some even suggest organising the STEM-academies at school as extracurricular activities so that all children can be reached and given the opportunity to acquire innovative skills. Also the collaboration between industry, schools, science and knowledge centres is important. Industry should indicate which soft (and hard) skills graduates need and which skills they lack. Roadmaps could then be developed to work on the acquisition of those skills as well in schools as in science centres.

3.3. ADVANTAGES OF INFORMAL LEARNING IN SCIENCE CENTRES AND MUSEA

The participants agree that the main advantage of science centres and science museums is that they have resources that schools do not have and can thus show exhibits that are fascinating and amazing. Children are often in awe faced with some scientific phenomena or they understand some phenomena they have learned about in school better through the exhibits, activities or demonstrations.

Because they have more resources, science or technology centres are often ahead of the schools in introducing innovative practices or experiments. They can thus trigger innovation in schools.

The centres can trigger the children's motivation for and interest in STEM by allowing them to engage in experiences and activities that are not always possible at school. Some demonstrations in the science centres also

combine fun and learning. They can convince children that science and technology are not dull and that science and technology are not only for nerds. Science centres can also trigger or stimulate soft skills such as problem-solving, creativity, critical thinking etc.

Science centres allow children but also (future) teachers to enjoy science in a "safe" environment where they can make mistakes, where there are no deadlines and where they can do whatever they like to do. Some exhibits invite the children to use their creativity but also their critical thinking skills. Thus they can be a trigger to acquire innovative skills that make them better understand STEM but also other subjects and soft skills that are also important for life beyond the school.

STEM-academies or STEM-workshops enable children who are interested in STEM to experiment in an out-of-school environment on a regular basis. Children meet with others who have the same interest and passion and acquire soft skills trying to find solutions for problems and communicating about them with their peers. These STEM-academies will have a greater impact on the soft skills of the children as acquiring skills is a long process. The coaches of those STEM-academies or workshops can be seen as positive role models.

Science centres are a privileged partner for schools, especially but not only as far as STEM-subjects are concerned but also as far as the acquisition of soft skills is concerned. Moreover they can also offer professional development courses for especially primary school teachers. They can inspire teachers to use new methodologies in STEM and help them lay the foundations for long-term learning processes for as well soft as hard skills.

3.4. CHALLENGES FOR INFORMAL STEM EDUCATION THROUGH SCIENCE CENTRES AND SCIENCE MUSEUMS

According to the participants the main challenge for science centres and museums is to attract all children, also children of less privileged families. Some participants think the science centres can reach all children through the schools, others think science centres have to collaborate with local organisations and NGO's. They all agree that science centres or STEM-academies (or other STEM-workshops) should reach out to these disadvantaged families.

On the other hand science centres should also organise workshops for gifted children who like to do more than they have to according to the school curriculum. STEM-oriented students should also be able to contact science communicators when they have questions concerning STEM-studies or STEM careers.

If science centres want to have an impact on the acquisition of soft skills, they have to collaborate with schools and other stakeholders in STEM and also focus more on long-term activities.

Science centres should also do more for the age range of 14-18-year-olds. By offering a wider range of activities for this age group they might possibly attract more girls to STEM-studies and more students to STEM careers.

Science centres should organise professional development for teachers based on the needs of the schools. Also the use of sophisticated scientific equipment by schools should be possible. They should also organise professional development for the science communicators.

Some participants think that the science centres do not offer enough opportunities for the children to experiment by themselves. If the centres want to focus on soft and innovative skills, then more experimental activities should be organised. At the moment children can experiment in programming (where there is no danger involved) but not in life sciences and chemistry. They do realise that this would need more supervision and for certain experiments even one to one guidance.

Although most participant teachers do not think that science centres should promote scientific and technical careers, they do think that science centres should inform students, teachers and parents about a wide range of scientific and technical careers and about the existing links between science, technology and industry. Science centres should motivate children to choose scientific and technical studies and careers without actually promoting them but by confronting them with positive role models. They should therefore make sure that the right science communicators work with children and pupils. Especially the corporate participants think that science centres should attract more students to STEM-careers by focusing more on the purpose of science and technology.

Science and technology centres should contribute more to the knowledge society and by developing better scientific literacy for all. Therefore they must enlarge their target audiences.

4. RECOMMENDATIONS

In order to meet these challenges sciences centres must:

- Enhance the collaboration with teachers, schools, industry, initial teacher education, university colleges and providers for continuous professional development on a structured basis in order to work out together a structured framework in which a visit to a science centre or museum is a step in the learning process of the students. This framework should focus as well on hard as soft skills. By enhancing the collaboration even more

schools can be reached and those (future) teachers can be attracted who are less interested in and motivated for STEM or who are not yet familiar with new teaching approaches that focus more on soft skills.

- Engage in a constant dialogue with these stakeholders to find out what their needs are and how the exhibits in the centre and the materials on the website or the activities of the science centre could be improved. By engaging in such a dialogue the science centres (and schools) will better understand their complementary role in the students' and teachers' acquisition of innovative skills for STEM (and other subjects).

- Reach out to new target audiences such as older students, gifted children, parents, grandparents, representatives of industry, local communities or organisers of holiday camps to see how they can help them maximise the impact of the visit to a science centre or museum.

- Bring the science centre to the school through STEM-academies or similar initiatives but also through mobile mini-science centres so that also children who live far away from a science centre can be reached and acquire the necessary soft and hard skills they need in a knowledge society. Invest not only in big science centres but also in smaller local science centres.

- Work on a strategy to inform especially older students and parents not only about scientific and technical careers, and about the links between science and industry but also about the future challenges for our society. Science centres should show students and parents that technical and scientific studies and careers are cool and can also contribute to solving the future needs of society such as the care for the aging population. Moreover they should focus on the soft skills that are needed for successful STEM careers not only in hard STEM but definitely in care STEM.

- Work together with industry to focus on the purpose of science and technology but also on the need for soft skills. Engage representatives from industry in the activities of the science centre and use them as positive role models. STEM coaches could play a crucial role.

- Help and assist schools that are interested in STEM to develop a STEM-strategy but also to organise continuous professional development (CPD) for their teachers in collaboration with CPD-providers. In order to enhance the acquisition of soft skills, inquiry-based teaching approaches should be privileged in these CPD courses. This should also be done in cooperation with the STEM coaches.

- Make an inventory with a detailed description of all activities that are organised by the different science and technology centres, by the STEM-academies, children's universities, CoderDojos etc. so that it is easy for schools, teachers and parents to choose a visit or activities for their children. At the same time a typology of science centres could be made.

- Collect relevant data (e.g. on the age and gender of visitors to science centres in order to enhance the policy and approach of science and technology centres.

- Focus on the professional development of science communicators and science facilitators in order to be able to adapt their communication to the different target audiences, to tell passionate stories, to substantiate a scientific theory when explaining experiments etc.

- Human resources services of the science and technology centres should not only attract people with a STEM-profile but also communicators with a different background in order to comply with the challenges mentioned in the previous recommendation.

- Focus even more on the development of simple learning materials that teachers can use or can develop further. Science centres could also have a repository of more expensive or sophisticated materials and tools that they could lend to schools or that schools can use on site.

- Make sure that all children have the opportunity to visit a science centre, attend a science/technology club or to be part of the newest developments on science in environments which are most approachable to reach them.

3 CHILE

- Natalia Molina, Psychologist conducting focus groups and transcriber
- Daniela Osorio, Psychologist conducting focus groups and transcriber
- Marcela Torrejón, Journalist
- Luz Lindegaard, Director of Education, Project Co-ordinator.

Feedbacks regarding the focus group process

- **General Process**

According to the commitment, MIM preceded to invite participants, considering the required profile for the focus group, on 7 and 8 August this year.

Unfortunately and despite of having confirmed, the first day a guest missed and the second day 2, both of them teachers. (Suddenly, it's form part of our culture, miss commitments).

The focus was handled by two psychologists, professionals from MIM staff.

All indications from ASTC were followed, and there were only a few minor difficulties, which are detailed below.

All participants appreciated the invitation, with very complimentary comments regarding the relevance of the study.

Our institution also welcomes the opportunity to be able to contribute to this study and was attentive to the final report of the same.

- **Concepts**

Regarding the "soft skills" and "science center" concepts and our experience in the focus group, we think that it was really important to clarify them before starting the conversation, because these were really confusing for the participants. We realized they were not clear because it was difficult to continue with the discussion, and because there were so many differences in the participants' understanding of the concepts. After this first experience, during the second focus group we decided to clarify these concepts talking about them in advance and leaving a graphic description on a white board. This was useful but even then, the participants that were not familiar with these concepts before needed to go back to talk about them in order to be able to give their opinion having the right information about the concept.

We think that this misunderstanding comes from cultural and particular language differences. For instance, we think that "science center" was confusing because when we talk about a place like this we think of a research center, universities or other kind of center that actually works producing science material and research. So, in our explanation, we tried to define "science center" as a concept extensive to museums, zoos, science buses, aquariums and other non-formal education instances.

On the other hand, the concept "soft skills" had similar misunderstanding because the participants were not familiar with the difference between social skills and technical skills. They just recognized "skill" as an ability to do something right. So, it was demanding to explain what "soft skills" are for the research and the social sciences field. Even when clear examples were given, we did have to use other resources and examples to clarify them.

- **Regarding the statements**

We have observations regarding how these statements were presented. There were a few that were formulated in a negative way, which caused confusion between the participants when giving an opinion. Other statements had too much information. So we think it would be good to rephrase them and even consider setting them as questions instead of statements.

Even though we did not modify the order of the statements (because we did not know if the order of them responded to some specific study objective), we think that grouping them by topics can be useful and can improve the focus group process and avoid being repetitive.

- **Guidelines**

As moderators, the material that you prepared was very useful for us (consent letter, information for the participants, guidelines regarding logistic and steps to follow during the focus group). We would have liked to have same guidelines about the report in order to know and accomplish what you expected (information, formats, etc.)

- **About the process**

The participation in this activity gave us lots of ideas and feedbacks regarding our duty as a science center and our impact. It also brought to the present many instances/projects that were developed a few years ago that worth to remember, and even think about putting them back in our planning. There where also innovative ideas regarding what is pending and what we could do to make the museum visit closer and turn it into an experience that generates impact.

Thank you so much for the opportunity.

Context

The follow report is regarding the focus group 1 performed on August 7, 2014, in Museo Interactivo Mirador placed in Santiago de Chile. This was facilitated for two psychologists, from the area of organizational development and education. It had a duration of 90 minutes, and was conducted according the guidelines given by ASTC.

Corporation

- Corporate Professional 1 (CP1): Male (65). Businessman, Manager from an Electric Engineering Company, experience in projects of renewable energies and as a college teacher.
- Corporate Professional 2 (CP2): Male (40). Businessman, Manager of Museology Company.
- Corporate Professional 3 (CP3): Male (35). Entrepreneur, CEO of a company of science communication, they develop videos and series to teach science.

Science Education

- Teacher 1 (T1): Male (45) University teacher of College subjects: pedagogy and mathematics.
- Teacher 2 (T2): Luis (45) Science Teacher of a school in Santiago.

Science communicator professionals

- Science communicator 1 (SC1): Female (33). Professional from the area of Marine Biology in charge of the center of marine studies from an important university of Chile.
- Science communicator 2 (SC2) Female (45). Professional from the area of science dissemination in a university and in a non-formal education institution.
- Science communicator 3 (SC3) Female (28). Professional from the area of Communications. She has developed science series for kids and videogames to teach science in schools.

Statements and discussion

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

T2: I think we should not. As a teacher, when you come to MIM, my colleagues, for instance, they come to the museum before and prepare the visit, they generate learning material (for the students to complete) so this way the students come with directions and after the visit we will give some time for them to relax and work regarding their preferences, but the first approximation should be regarding the content, It cannot be disorganize.

CP3: I think the statement is right, but I think we would have to do a difference between a visit with the family during the weekend, some fun moment and relax also close to the knowledge, and other experience as a visit with your class, a group that has an objective, that come to take experience to study or analyze in a classroom.

SC3: I also think the same, in the case the students come with the class, the should come prepared, with learning material, and knowing what they are going to do/learn, but yes, in the case they come with the family, in that case they come to have fun.

SC1: But I think that in any case, when they are choosing to come to a center like this (MIM), they are choosing at the same time a sense of education, something, learning. So, is true that if they come, they go inside and check what is there, they test, they play and interact, there is going to be an indirect learning despite they are free and with not guide. But is true, if there is a guide, a protocol, a monitor, something that leads the experience, it makes the knowledge be a step forward. And this is really important, because when the children come just like that, they will enjoy but they will see what they already know, but with this help, this link they can go a step forward, in this sense I think is really important that always be a monitor or someone that can orient them.

CP3: But what you have told is always there, because they do not come alone, if they do not come with the teacher they come with the parents....

CP2: Yes, I think the question takes you to mistaken, because is clear that you come to the museum to learn, but the question is asking so direct about if is convenient that the museum works as an extension of the classroom, I think that is where is the mistake. From my point of view, they experience in a museum it has more relation with the non-formal education than the formal education. So, if we try to equate the school experience school and the museum experience, the museum lose its reason of existence, which is teaching from other angles, teaching from the experience, form the contact, from the senses, etc.

T1: I think the idea is also about create an enlightenment process, in the sense the people have an intention of learning, and there is where the museum has the characteristic of stimulate the "learning by doing", from the perspective of find new phenomena, new spaces, etc. This situations is when creativity comes out, develop ways of thinking, etc. And I am not sure if we restrict and give directions to visit/discover this space, it will contribute to the learning or precludes the possibility of developing this other kind of skills.

SC2: I also think that the museums accomplish their objective from the non-formal education. From my experience one of the problems that school face when teaching science is how to captivate the children`s interest, so if we make of the museum an extension of the classroom there are going to lose attention and intention of learning science, is a fact. So the museum has to present the content in a fun and interest way, as they do, where kids can play but with a guideline, where monitors lead the experience and incentive the interest. Considering the museum as an extension of the classroom is a big mistake.

CP1: I have a doubt that I need to solve to be able to answer, what are we understanding as a "children",

because for me is not the same a kid of 5 years old to one of 15 years old. Because if I make the distinctions, primary students, for what I understand of psychology, they make basic questions as why happens this, or that, in that case the monitor should give answers based in games to explains phenomena. In that case of kids around 10, the visit should be based in a specific program but full of surprises to catch their attention, but something that implies finding methodology and content. And now, for elder students, It should be an extension of the school, where they are coming to learn a specific topic, where they should to homework, etc.

SC2: I think the museum accomplish two objectives, one is the divulgation and other is the appreciation, divulgation in the sense of generate the first contact with science and this "new space", the generation of links and surprise, and divulgation in the sense that we can come to experience the abstract contents that students usually study at home, in that way it can be an extension of the classroom.

Science centers work better for boys than for girls.

CP3: I think the answer depends of our cultural context; the museum experience is not out of this. You just need to go to a toy store and check what kind of toys you find for boys and for girls, pink and purple and the others. From the begging we are not promoting engineers/scientist women careers. I think the museum as a space for kids has to take part of this, and try to fight this difference.

CP1: This is a really misogynist statement, is regarding what the women has to do or not to do, I disagree to that. I would like to say that, I don't really remember the name, but "Ipatia", the Euclides or Pitagoras daughter, I am sorry if this are not the exactly name, but I have read that she was who wrote and discover everything and no her father. Same happens to Marie Curie and other scientists that have not been recognized. But I think being a cultural issue, I think is not the labor of a museum take part of this, and if the museum does something it has to be in the order to promote the interest of the children. If the like mechanical or electricity, they should promote the interest in learning.

Is just like if for us, as CEOs, it would be compulsory to hire mayor number of women employees. I disagree to that. As a CEO, I hire who is able to do something, in fact, now we have a project that has 10 locations photovoltaic ad Aeolians in Chiloe, and who is in charge of this project is a women, because she is who knows more about this topic and project and people manager, and workers (men) respect her. Our Finance director is also women, but I guess we are a "special" company; most of the companies are not like that.

In my case I hire who works better... "The right men in the right place" and "the right women in the right place"...

SC2: I do not have statistics to say that girls visit the center more than boys or the other way round, but I think there is a gender issue, even more when we consider ages, for instance, in the primary stage I think there is not a big difference: both, boys and girls enjoy and learn as an equal and they like same stuff, they explore and there is not a big deal.

But during the high school, the interests change and there is also a social and economic factor here, the students see some careers really far, either because they can`t afford the college or because they don't believe in their self as students of those kind of careers, they don't believe of having the capacity to study science careers. In this context, the museum should offer equal options and alternatives.

CP2: I agree that the museum does not have the obligation to take part of this. But this is a really difficult statement. And I could affirm just the opposite... The museum or this kind of centers work better for girls than for boys, because boys are more brute/gross (no delicate) they just go and they move everything without caring, while girls watch everything carefully trying to understand. So, I guess talking about gender discrimination from one side or other, is something that I think is precipitated.

SC3: I have assisted to "kid's focus groups", where they have express that they don't want to be differenced. They don't want to have toys for boys and toys for girls. I have seen in some countries that there is now a law that regulates all this marketing practices around the toys, so there is not in the supermarket anymore, a pink corridor and a blue corridor. In this sense the marketing it has to be neutral, using neutral colors. Is like kids feel, they don't want this difference and they don't like to be scolds because they want to play with a doll or with trucks, and that change start from the education of the kid`s educators.

Tr: I would like to add something from my experience that can contribute to think about this topic. From last year I have been working in a kind of science workshop in high schools and all of my students are girls, and not because I have chosen them, the applications are full open, is just because they are more interested

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

SC3: The thing is that in the school, they teacher talks and the half of the students is not even listening or they don't hold/learn anything, so, In this sense the methodology of experiencing and learning by doing and get their own conclusions trough the game, is something that the school should take to do the learning process more effective.

T2: I think that there is a deep problem here, because in our national school programs, a big percent of the activities are experimental, but the teachers and the school don't have the resources. The teacher don't have the expertise, so finding museums/centers like this, allow to the students to experience the phenomena. But in the school, there is not more than ppt.

CP2: Being strict to the statement, I agree that schools have to learn more from the center than the other way round. Just because of that, if you see the structure of our classrooms, is a retrogressive structure, the only thing that has changed is the material of the board, from blackboard to a whiteboard, and that's it. The thing that you are learning is the same.

T1: In my opinion, In think there is something regarding the expertise of the teacher, most of them don't manage didactic of science, so even if they come to the museum is difficult for them to replicate the methodology in classroom, even with resources.

SC1: That's true, I am studying a Master in science didactic and big parts of my classmates are teachers, and they complain about the preparation, the resources but also about the time. They have no time to prepare new activities, because they are lecturing too much time, so there is not time in their working hours considered to prepare new material. In this case coming to the museum or visiting websites where they can take this kind of experience and material is really useful for them. So the statement is right. And the other way round, I think all of us who work in science communication have a part of the school as well, from the perspective of the content.

CP1: I think is convenient for the school the existence of this kind of museum. When I study in the "old school system", my classroom was the laboratory of chemistry, we had all the materials, and nowadays the schools don't have that. So in that time if we had come to a museum like this, we could have learn, but maybe not so much as they students learn today, because today the school doesn't have nothing more than a whiteboard. The education system is so deteriorated that nowadays museums like this take a big importance.

SC2: Yes, I think we agree. But I also think that the museum can learn from the schools, from their needs. So this way the museum can work and impact regarding the real needs of the context and the real needs that the schools have.

T1: I would like to add something; I think the museum does not promote only science learning, through the experience you also are helping to develop communication, sharing, team work, and other skills.

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

SC2: I would like to ask first what kind of science center we are talking about, because for me a Science center is where you produce science, where research is done. Different is a science divulgation center, where the quality is important and the objectives of the institution (moderator gives the explanations).

T1: I think that even if MIM doesn't have the divulgation and the promotion of the science careers in their strategic objectives, is something that is inherent and MIM should make it explicit in their mission and vision as organization. I have the experience of ex-students that now are in college, studying physics and chemistry and they were my students from x school, MIM is an instance to spark creativity and interest about this topics, is something that actually happens and It should be more "visible" even when is not something that is not sought, not intentional.

CP3: Is like a collateral effect, but MIM should work for making the science "popular", close to people. If the focus is to promote science careers, so the science will be only for scientist and not for the people. If what we are looking for in a few years is to talk about science to the taxi driver, so the objective should be other.

SC1: I think that yes, MIM and the center where I work (there are people working on research and we are two how do the communication) the objective is to divulgate and work on science literacy for everyone, you give the information so science closer to people. If you do that, so the promotion of science careers is a secondary effect, you create interests and they could choose a science career or not, it depends of the person and what they found is the experience.

CP2: I agree to that, from my point of view, I think is not the labor of the museum, even if is interactive, the objective is to show, to create interest about science, if from there arise professional callings, is something that just happens.

CP3: If we compare with some other science center – museum, the objective for instance is not creating masterpiece author, is to promote the joy trough the art, same with science.

SC2: Make the science close.

CP1: I think the same; the museum should look to make science popular, close to people. It should be a contribution to the culture of a place and not marketing for careers.

SC2: If that is the case, and they try to promote college`s careers trough this kind of places, maybe some people wouldn't come.

CP1: I think is not the case of MIM, you have an electricity room, where is the X company, is also there the mining industry, is something that is present in this museum and industry has shown interest for establishing links with MIM. In this case is a fact.

T1: In Chile there are also government funds, looking forward this connection between science and industry and this way, promote economic and social developing. Interesting because this connection is actually hap-pening. Interest is as well see the possibility of creating this links, to evaluate and make the CSR process and the ecological impact of the industry transparent to people.

SC2: I think they actually do, not only here, I have been in many interactive museums around the world, and there is always something about industry and their effect to the environment. This relation, should exist also in other educative materials, scholar books for instance, this helps a lot to kids to associate the industry to the impact, and what to do to help the environment.

T2: I would like to add that this connection that you talk about is actually present in the study programs in schools; this connection helps kids to understand the relation between both.

CP2: In my opinion we need to do a difference between industry and brands, I think is good for both to hold this relation with the energy, the mining industry, but I think when this relation become functional to specific brands, I think they could start working regarding the particular interest, and I think that shouldn´t be done.

CP1: However as a company and the different projects that worked here (who put their particular contribu-tions), we fought looking for install and make visible the brand here, even when the museum didn't agree completely to that, so we put our logos here and there on the sly. We are also looking for marketing, we need to understand that even when we want to do contributions, if doesn't return the investment, so is not profitable.

CP2: In my opinion, that relation can be, but the content that a museum like this offer shouldn´t be given by companies, it should be the other way round. The museum should decide the contents that they want to show, and look for the needed support, if that "support" implies have a logo in the museum room or not, that is other issue, but not the other way round.

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

CP2: I think that museum gives you an experience, it can surprise you and get your attention, showing new worlds, etc. but if we talk about soft skills, that is training.

SC3: I think is more important the experience that you get, and the association that you make space- emotion than soft skills.

CP1: For me that is not the objective of a museum, for me soft skills is training.

SC1: I think if the kid comes to the museum and he/she confronts a situation where it has to think how that works, it can be a soft skill development. We know that coming one time to the museum is not going to give all the training that the kid needs for his/her life, but if this kid goes to different science center, and is something that he/she continuously does, so there can be a soft skill development.

T1: I think as you said, there are different levels of soft skill development, and in my opinion the museum contributes to that, is true that you will not develop a skill coming just one time to a science center but there is a contribution to start the development process, making the kids wonder, etc.

T2: A few years ago, there was a museum fund contest where you can participate and win science materials. We were working for three months, where I was able to see development of soft sills, negotiation, tolerance, cooperation, team work, etc. Has been one of the best experiences of my career, really satisfying. We work doing hummus, we work with Californian worms and materials that MIM gave us; the students were in charge of this, and they learn a lot, and I was not the only happy, their behavior improved notoriously, so also parents and the school, and them self where happy about it.

SC2: I think we could see results if we program visits to the museum periodically, but we cannot expect soft skill development from one single visit.

CP1: I disagree to the idea of the museum doing the school jobs; they should have better labs and resources and not be expecting that the museum gives everything.

T1: As a long country is difficult to have access to this kind of centers, so what MIM does, bringing the science to children of different parts of Chile, and even more, with this kind of extension programs, increase the impact they are working for.

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

T1: Is difficult to understand enough efforts in this kind of topics, nothing is enough to make science closer to kids.

T2: I think is not the case of the MIM, the same experience that I mentioned, they work for a real impact.

CP2: In my opinion, this is a tricky statement, because of the "enough" word, in that sense we could ask to ourselves; does some do the enough to promote science and innovation? That supposes a perfection grade that nobody achieves. If we remove the word "enough", I could say that this museum does more than other center, you just need to visit other and you will realize the difference.

T1: I think one thing is what this kind of center does to promote science and other is the impact that this "efforts "have. So in my opinion is not about the numbers of initiatives that they have, is the impact.

SC3: I think if we talk about pending and other "efforts"/initiatives that these centers could work on, this are to establish more links between the science center and other institutions that are also creating content. For instance, I would like to get more feedback from the museum regarding the series that we create, maybe have a space to extend that material to teachers and contribute to the education to the creation of more synergies.

SC1: In my opinion, we need to make a difference between science center and MIM, MIM has as part of their organizational objectives the promotion of science, but is not the case in the center where I work, as I mention there are many people working on research and content creation, but nobody see and promote the divulgation of this, nobody gain "a point" for doing it, in this case I think we are not doing enough to promote what we do.

CP1: I think is also relative to the politics, one positive thing about MIM, is that even when the executive management change every four years, the people that work here is the same, which helps to evaluate and see impact (regarding what T1 has mentioned).

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.

CP3: There are some soft skills that you can develop in extracurricular activities but there are some others that you develop in centers as MIM, everything is a plus. In my opinion there are some soft skills like “sense of wonder”, “interest to discover” that you just develop in centers like this.

CP2: I disagree to that; I think you can develop soft skills practicing sports, dance, with friends, etc. I don’t think some skill development is exclusive of one activity or specific centers. Is difficult for me to think that exist soft skills that you can develop in MIM that you cannot develop somewhere else.

CP1: This is a word that I am learning after 60 years of career, why is not call ability to communicate, or ability to negotiate?... for me this are skills that you learn during your life, in your classes, in your work, so of course that they can be develop outside the museum, and there is not the objective of this centers.

CP2: ... Or can be develop here, but is not exclusive of the museum...

CP1: But is something that is regarding to science, no to the museum in deed, otherwise let`s create a soft skill school in MIM. I s not the objective of the museum.

T1: I think the term “soft” is what is making this confusing, it makes us think that is something simple, but no. I think we should think skills as transversal abilities that make us work and live better. On the other hand we have the cognitive skills which are develop in fact in school or science context and no others, but of course they are not exclusive to the museum.

T2: I disagree to that, I think that are skills that you necessary develop in this kind of context and not others, like how understand cause- effect by learning by doing, technique abilities, and also the capability of wonder.

CP3: I think that’s the thing, it depends with what we understand by soft skills.

SC3: I think soft skills you can also develop them outside, by doing other kind of activities, like art, sports and dance, not only here.

SC2: Yes, I think is complimentary, and not exclusive of the museum.

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.

CP1: Is not the center`s responsibility.

T1: I think there is not suck this as place for developing technique skills and soft skills only. For instance, in the school, kids learn how to solve mathematics problems; they develop analytic way of thinking, which they also can develop trough problem solving in a science center. In both spaces they develop the soft skill.

CP2: I think that this statement make us question the education system, in my opinion there is fundamental that school design activities to develop soft skills, the difference is that soft skills are not learnt through a blackboard, is something that includes sharing with classmates, sports, volunteer and other kind of activities.

SC2: I also disagree to the statement, because is not that you are going to waste time teaching soft skills, is within the activities and contents that you teach.

T2: I think as a teacher, the school program include develop of soft skills, and we also have to evaluate. The thing as a teacher and also my colleagues, we are lack of abilities, preparation and methodology to develop and promote this kind of skills. In that sense going out of the school and going to the center, give that space to talk about what they learn, they saw, etc. Most of the teachers and schools that I know, even when they have a school program to follow that includes soft skill development, they do not give/have time to design this activities, they are too busy preparing the kids to obtain a high score in the SIMCE (national test for "learning" performance evaluation) so other abilities as team work, communication, etc; are just in papers and no in the real kid`s learning. They just focus in what is a result for the school.

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

CS3: Is really similar to the other question. I think is has impact, even more if the kid already like this areas, it will elicit even more interest for science or the career that they like, and have an idea of what they could do in the future.

SC1: I think it helps to see the science closer, and that they also can work on. The science center can help to discover, learn and wonder why not they could work on creating new things, new theories.

T1: I agree, I think there is an impact, as a kid as we are blind, we can promote interest, just like a magician is performing, we want to know how the magic has been done, same here, you show and invite to discover, you generate the question and play. Also they cultural capital is something that influence the decision to go into a college or not. Even more in kids from villages, when they visit this kind of center, they meet new worlds.

CP2: I agree, to become lover of something, you have to know it first. But also depends in the "quality of field that the seed is going to grow".

SC2: I think it has an impact, when you show something different to kids/teenagers; you make them question and think about that they also can do it. When you show something that they feel so far from their reality, they think about "what if... I study... maybe I also can..." etc.

SC1: I would like to talk about a personal experience; my younger brother is now with me in Chile, he is 15 years old, he has failed eight courses, he does not want to study, he is not a bad boy. He has been here for three months and is working with me cleaning the aquariums, he is my assistant when I have scholar visitants, we go to get samples, etc. Now he is leaving, and he has asked my boss if he could come back to work and learn. So I have seen changes, now he want to study, the environment and trusting on them makes big differences.

SC2: I think the facilitators (museum guides) are really important too. Because they been young and college students, the see them really close, so the school students see them as a referent. Is not a scientist who Is teaching them, is not an Einstein.

SC1: Yes, that is really important, make the science closer. In the aquarium we also don't wear white coats.

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

T2: I think it depends of the teacher, how they are going to mediate the content, if you come to the museum without preparing class and the kids, so there is not going to be long term learning; they need to associate content to experience.

T1: I agree to that, it needs a systematization of the visit to long term learning; otherwise the visit becomes just nice memories.

CP2: I think, as we mention before, that the role of the museum is to open perspectives, open to new worlds, but how that is going to happen, depends of every child. Even us, so many times we have been in situations, with cousin or siblings in a situation that was really important for us, but not for them, they maybe do not even remember it. So same happens here, the impact depends of every child. Museum has the task to give the materials, give the space, facilitate the process, but the impact is not something that you can control, what happens after, it doesn't depend of the museum.

SC2: Yes, maybe it will not impact 100% of the visitants, they do not discover the world here, they have some many devices now, is difficult. But there is a percent that is going to be strongly impact, even impulse to study. Other maybe from the memories and the association.

CP3: For a long term impact, it has to be a systematic visit. But there is for sure an impact. In an international conference, there was an astronaut girl who was emotional and was giving thanks to the people from some science series production, because when she was young she watched the series and inspired her to become an astronaut, so the science divulgations- productions- spaces in did have impact.

Context

The following report is a summary of the second focus group performed on August 8, 2014. It took place at the Mirador Interactive Museum (MIM) in Santiago, Chile. This was moderated by two psychologists, from the two different areas (organizational development psychology and educational psychology). The discussion lasted around 90 minutes, and was conducted according to the guidelines given by the ASTC.

Corporation

- Corporate Professional 1 (CP1): Male (35). Digital consultant in the area of data display. He is also a college professor.
- Corporate Professional 2 (CP2): Female (31). Entrepreneur at a Company that develops educational technology.
- Corporate Professional 3 (CP3): Male (38). Entrepreneur.

Science Education

- Teacher 1 (T1): Female (58) Science and technology school teacher.

Science communicator professionals

- Science communicator 1 (SC1): Female (33). Professional from a program that disseminates science and technology to schools through non formal education activities.
- Science communicator 2 (SC2) Female (37). Professional from a foundation whose purpose is to establish a connection between science and society, going to different locations in Chile and teaching science in a fun way, inside a “science bus”.
- Science communicator 3 (SC3) Female (55). Professional from the area of Education at a Science Center.

Statements and discussion

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

SC2: I agree, especially considering our national context and what our schools are. A school in Chile is different from a school in Finland or any other country. In general and considering our experience and observations, science classes expect students to learn by memory, with little opportunities for hands-on experiences which are vital to develop soft skills. It is precisely in places like this museum and other non-formal education centers where kids can be invited to discover their curiosity, to develop it and they stand as a place to do everything we would like schools to do. In our reality schools don't do that, a lot less in science. That's why I think that science centers and museums play almost a more important role than schools for the development of all these skills. I don't know how it is in other countries, but in Chile from first grade, kids see their classmate's back of the neck and they never look at each other's eyes again, so how can we require them to work as a team, to be flexible, to be empathic if we are going on the wrong way? So I think it should be full of science centers. Playgrounds, everything should become a museum in order to develop these abilities.

SC1: If kids don't like to go to school very much, then we need to encourage them to like to go to museums. In my experience in museums, kids like to discover knowledge that invites them to experiment in museums better than the rigidity of schools. We have to strengthen the freedom in the field of academic training.

CP2: I think museums have an advantage that schools don't, and it is the fact that they don't have pre-established tenets. In museums there's nothing pre-established. Often times, when people go to museums, they go with the initiative to marvel at what they see, like when one goes on vacation. I think that's very valuable and museums should encourage that. It is important to mention that museums aren't the only places to do that, there are other social spaces like fairs, stands, etc. Sometimes museums fall into the same thing that schools do, which is to be a house of four pillars with a roof and that it doesn't get out of that structure.

T1: A couple of months ago I brought a group of 6th graders and 9th graders to this science center. I brought them with a simple document with a few questions:

- What tour did you do in the museum? Write down the names of the exhibitions.

- What caught your attention?

When they submitted the papers, I was surprised. I even graded them. The students kept talking each day about their experience and it was impossible to stop them. They were very happy from the moment they entered the museum and had that freedom to go wherever they wanted to, under condition of turning in the paper. I had another experience with school students in an afterschool program and they were so enthusiastic and showed great creativity. I realized then that inside the classroom one disciplines students. Nevertheless, when they were in the afterschool program they were leaders. I think schools have to open their doors to this alternative, because kids can discover what they like, what they are good at.

CP1: I disagree. I think that between just having fun and turning a museum into a chilean school as we know it, there are a thousand shades. I think that constructivism and all the other pedagogical methodology have to blend in together, each one has its turn. As a supplier of one of the exhibitions of MIM, I say no. Kids should not just enjoy. I think that enjoyment by itself takes away depth from the educational experience. Don't get me wrong, I think it is necessary to enjoy, education shouldn't be a burden, but it's

why there are guides in museums, because kids go there and they can jump onto the exhibition without understanding what's going on with a certain physics phenomenon, etc. So museums should be used as a tool to helps kids to understand concepts that are taught in a strict way in schools.

SC2: But I also value your point (to CP1) because we are talking about science centers and we teach them to open their minds to science, but we urge them to fail because a scientist fails ninety nine times before dis-covering something. So, it's true that enjoyment is a large part, maybe the goal is that kids enjoy but not just enjoy, because they have to go through the adrenaline that a scientist has that motivates him/her to discov-er what is going to happen, to know that he/she can be wrong and that there is nothing wrong about that. So, if enjoyment is defined by that, I would agree.

CP1: Exactly, there's a tolerance to failure that every scientist develops and he/she shouldn't scape from it but deal with it.

SC2: If not, the science museum could be a theme park, not a science museum. A science museum has to arouse curiosity, take you out of the box and that's uncomfortable. At the end you enjoy, but because you were uncomfortable in the beginning. I value that part of your point and I agree (to CP1).

T1: I do not see enjoyment as an extreme. We had finished some activities with 6th graders about visible light and when they came here they found that in the museum. And it was beautiful to see that they could associ-ate what they had learnt with what they were looking at. That's enjoyment. Now, if there's some ex-hibition and a knowledge that students aren't familiar with and they don't know about it, one as a teacher knows that and then you use that new knowledge in the classroom. In a science center, the student gets to know, observes, draws conclusions and finally, when the time comes to study those contents one reminds them or they recall that experience.

SC3: I believe museums have to trigger, they shouldn't become schools. If they do, they would be tedious. It's not our responsibility; museums are non-formal education spaces, so we have to create experiences, exhibitions, spaces where kids are triggered. That's it.

CP3: I agree with you (to SC3) and I also agree with you (CP1) because the statement is very radical. It is this or that, black or white, when in reality it is very hard to bend to one or another.

CP2: I don't understand why you associate enjoyment with fun. For example, to enjoy something is the most rewarding experience, what you just said (to SC2): to fail once and again and when you finally hit the target you are enjoying, you're not having fun. To enjoy for me is similar to the Greek concept of joy of the soul. It doesn't have to necessarily be fun.

Science centers work better for boys than for girls.

SC2: I totally disagree, because I see the opposite day after day. Every child is an individual, regardless of his or her gender. In fact, there's a lack of strengthening science among girls. That's what is missing. To stop buying them the kitchen kit or Barbie dolls. They love to play with electricity too and there's no space for them to do that. So, in museums or science centers they are all kids, regardless of their gender, and that happens with adults, grandparents, parents too. We all become kids again, with curiosity and a desire to know. Therefore, I totally disagree.

CP2: I think there is a tenet about science and women. It has been established beforehand that women are terrible for science, for math and in my experience, we had many museums travelling along Chile and I could see more girls interested in science compared to boys. And girls are also more bookish that boys, teachers have always said that.

SC3: In the experience we have had in the museum, I think gender doesn't matter. The museum works for boys and girls, you see both of them enjoying when they come here. I don't see any difference; I've never seen girls or boys bored in front of an exhibition.

SC1: I think that hypothesis is very sexist (laughs).

CP1: That statement frightens me. It frightens me because I hadn't noticed that before, it wasn't a question for me if what I did or the exhibition in a museum worked better for one gender or another. And that can be due to two reasons: the prejudice is so settled in me that I'm not able to see it, or that I simply work equally when I create resources or products for science. But I think when we see the quantity of enrollment to scientific careers it is clearly a boys' game.

SC2: It is actually 80% girls. I am also a teacher... Wait, girls or boys?

CP1: Boys, in college scientific careers. We are talking about hard science, like Physics and Mathematics.

SC2: Oh, I was thinking about Biology and Biochemistry, and there are more women there.

CP3: We would have to look at the statistics, but I think and agree with you, there's an inclination. I have sons and daughters and they are so different. I don't have any bias, but clearly the difference is there and that difference is great. And sometimes, as human beings or because of raising, there are boys that are much more like girls and girls that are much more like boys, to say it somehow. I don't care, it's just the way it is. And they have more inclination towards an area that could be seen as more masculine or more feminine. Nobody ever wonders if a man who's very sensitive is too much like a girl, I don't know...

SC1: Those are different abilities.

CP3: Exactly, and they are harmonies that are hard to measure.

SC3: I agree with you, I had never asked myself before if this works better for boys or for girls. We had never discussed that before. In our planning and creating process it is not relevant, we never have asked ourselves if we are doing something for boys or girls.

CP1: That's why it frightens me, because if I have a bias I have practiced it unconsciously during all my life or in all my projects.

SC2: It attracts my attention that if there are 11 statements to discuss worldwide and one of them is dedicated to this matter... it really attracts my attention.

CP2: But don't you feel that there is a prejudice about women, especially about women and math? That there are doubts about their abilities?

SC1: I don't think that people doubt about their abilities, I think there is a social and cultural bias. For example, we work with many women scientist and we always try to deal with the fact that being a woman scientist also allows you to be a mother, you can develop other abilities in other areas. There's this idea that you are either a scientist or a mother. I think that idea is more of a cultural bias that a doubt about their abilities. Because there are many women that hold themselves back.

CP2: In my experience, especially in other regions, it always attracted my attention that, maybe because the exhibitions were designed mostly by women, girls were more interested in the exhibition compared with boys. It was much harder to explain an exhibition to the boys.

T1: In my experience, I worked in pharmacy and chemistry for many years and girls stand out in their abilities to work in a lab. They supported the boys, but in they were equal in their performance. Here (in the museum), I haven't noticed any difference. I've brought mixed schools and this is the first year I work with an all-boys class. In the classroom there is a big difference. Boys are faster, girls are more thoughtful and I think that's the difference, but that doesn't mean that one group is more capable than the other, it's about the time they need.

CP3: That may be the reason why girls enjoy the museum more... Could be.

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

SC1: I agree, because museums or science centers work in an innovative way. Schools, on the other hand, are under a set of rules that isn't up to date.

SC2: I think they are different things. And are complementary looks. I feel this question is set out as a compe-tition. We should take out the competition and see each other as a complement: there are museums, there are schools, there are parents, there are field trips to the woods, there are so many different spaces and we all have to learn about each other instead of one learning more about the other. It is about how all these different elements add up to develop these soft skills in our children.

T1: I think that many schools until today, either because of time, money, number of students, lack of class-rooms, lack of labs, focus on the theory. The fact of having a science museum or center is a great support for the work teachers do inside the classroom. That's undeniable.

CP3: I think that when the MIM opened its doors, that's what happened. It was like "Oh, my! This is wonder-ful; a place where you can experiment with all these things you can luckily go through when teaching in the school". That speaks badly about school teaching, but I don't know if we can talk about a competition.

CP1: I think the day-to-day is vital. How teachers solve, inside the classroom with 30, 40, 50 students, how they solve the educational method instead of the great strategies, programs that are created by the Educa-tion Depart-ment and the school community, I think we can find an intelligence there, in the teachers, that if we're not able to see it and make the most of it we're absolutely blind. And that can be translated, organized and systematized, into solving things like how to encourage a kid that is entering the science center all messy in a certain matter that is complex, considering that his/her behavior in group is different to his/her behavior when he/she is by himself/herself. Teachers are specialists in all those things. I think the space to test that day-to-day is not something we can do in the museum; it's something they can do inside the classroom. Maybe this is a subject that could be part of another research or other activities that can mix both dynamics.

SC3: I think that the part of the question that establishes "can learn more" is the complex part. We could not say "more", I think we can both learn from each other. I agree with SC2, we are complementary. Maybe what they are trying to say is that schools use methods that haven't evolved as fast as one would like consid-ering our decade, our constantly changing society. These kids were born in the technology and communica-tion era, and want every-thing to be much faster. In the museum that's what happens, there's agility, there are different dynamics and they are quicker. I think that's where the question is leading. I think the school could look at the museum and see that it uses these new methods, as SC2 says, that kids don't look at their classmate back of the neck all day long. But I also think that we have to recognize that schools have a much longer trajectory and that we can also nurture from many things teachers do and their experience.

CP3: Maybe the question refers to if it's better in the sense of something very simple: if somebody tells me that the light acts in a certain way, in a classroom it's very likely that I am just waiting to go to break and I'm not going to think about it. But I come here (to the museum or science center) and I see it in an experiment and it is an expe-rience that I will never forget, so I learnt better there and that's real.

SC1: School and museums are two different things. Science centers and museums are more based on experi-ence y obviously one learns more by experiencing something rather than reading a paper.

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

CP1: Why not?

CP3: It's like asking if it's better for boys or for girls.

SC1: I think this statement is absurd, I disagree. If you like an area, you go to places where that area is devel-oped and they obviously encourage that interest indirectly, there's no way to restrict that.

SC2: I disagree because I wouldn't like museums to promote science careers explicitly. But I agree with mu-seums promoting scientific thinking. It's not only about promoting science careers because, at least for me, science is culture; it's not only something related to a career. To work with the scientific method is useful in any career. I think focusing on promoting science careers would be detrimental for both museums and visi-tors.

CP2: I think museums do that unconsciously all the time, don't they? They show that there is a possibility to dedicate your life to study something, to create. So I think they open a gate to a whole world of possibilities.

CP1: For me, the role of a science center is to move science closer to daily life. I don't think all the kids that come here get out of this center wanting to be scientists. They probably got out knowing that science has much more to do with them than they thought before. The museum does it undercover, because promoting scientific thinking is to promote science and the work related to science. Personally, I don't believe too much in the scientific paradigm but I think that as a human being, as general culture, one has to have an opinion about the scientific paradigm, even when I am a detractor of it. I agree with the statement, to promote sci-ence careers is not the role of science centers, they do it undercover, but their basic role is to show that the scientific phenomenon is something we experience daily, the child in this case.

CP3: I wonder... if one goes to a literature museum, what happens there? They promote literature. I mean, if I have a talent to be a scientist and they promote that in the science museum, that's great! And it is the same thing that would happen in a literature museum, an art museum, an aerospace museum. I don't think that's wrong or anything like that.

T1: I think they do promote science careers, but how? Through the different exhibitions! And that's the idea. If a student is interested in one area, later he's going to study that. That's why we need to take students to different places, different museums so they have a wide variety of possibilities to choose from. And not just staying inside the classroom.

SC3: I agree with you, maybe indirectly different vocations are stimulated. In this place, all the exhibitions are related to science, so obviously they will stimulate science careers. But our objective has never been to promote intentionally science careers; we have never designed an exhibition having that in mind, because we are a museum open to all different kinds of people. And I also agree with you: not everyone who goes to a science center is going to end up being a scientist. The idea is that children go to different rooms inside the museum and different exhibitions in accordance with their interests.

Science centers rarely focus on the relationship between science and industry.

CP2: I disagree, because it is built in. How can you talk about electricity without talking about industry? It's impossible. The demonized industry is the practical way in which these science contents become true.

SC3: I agree with you.

T1: I think there's a direct relationship between both of them, absolutely.

SC2: But I think this museum (MIM) is an exception showing that relationship. This museum has a very im-portant role: it is an intellectual niche that other museums are not taking; it gives visitors a wider look. Think-ing about science centers for kids, I agree: they rarely focus on this relationship and MIM is an excep-tion.

CP2: But it also has to do with science, I think. Science has a clear relationship with industry. Industry is a lot of times the one which finances science, it helps to make progress in science. I think it's important to address the industry when it's necessary.

CP1: I think the relationship is very controversial. I think there's an ethical dimension in that relationship, the development of the ethical dimension in kids. I agree that science has a direct relationship with indus-try, but I think it is a very complicated relationship in terms of conflict of interests. For example, in Chile the mining development of copper is a big part of the industry and I understand that big enterprises want to promote the work in this area, even if it is in science museums. But there's also a huge environmental impact behind mining development and I think science centers have manipulated themselves in terms of industries promo-tion.

CP2: I disagree a little. I have never seen something rude, explicit in this promotion. Every time this subject, industry, is addressed in this environment is because it's necessary.

CP3: I was thinking about something completely different. It would be great if all workers came here (to a science center) because their creativity awakens other possibilities. Inside the industry, we need our work-ers to be more creative, more self-sufficient; this is how they become more valuable. There's an area of the industry that has been demonized (banks, mining) but there's another area that's far away from that, and there are a lot of people that believe that the only way to carry this forward is to empathize with workers, to recognize their abilities, their intelligence. I think that's a great tool, beyond using it to promote my en-ter-prise. That's unethical.

SC3: This relationship between industry and science has been a hard thing for us. I agree that they rarely converge, and they converge because industry tends to use science centers as marketing, and that's where we find willingness from enterprises. It's very rare to find a sponsor that contributes selflessly. The industry that supports an exhibition wants a profit. That's the reason why we've had little relationship with the indus-try.

CP2: Sometimes there are created interests that are legitimate. Even when it could be a created interest, they have information that is true and that needs to be spread out. It depends on up to what point they converge (science and industry).

SC3: I agree with you. When there's a relationship that converges with science or any other social interest or when it is a contribution to society, that's ok. The conflict arises when it's not that way, when industry im-poses the contents that are going to be shown at a museum.

CP1: I think science centers have to be very careful. I am not demonizing any industry, I belong to one, but there are subjects to which museums have to pay special attention: what is the relationship they choose to have with the industry? That's something to think about, because I think most of the time industries have little to say about science. An example of that is healthy eating. I don't think food industries have much to say about it, because healthy eating has been damaged by industry.

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

CP3: I read somewhere that traumatic experiences are the best knowledge focal points. Traumas are not always negative, they can also be positive. One never forgets an episode of shame, a miracle and I think this is an answer to that statement.

SC2: I think it depends on the soft skill, and it also depends on the exhibition. I think this statement is too broad, it's hard for me to say if I agree or disagree. I do think one acquires skills that are useful day-to-day, I don't know if they persist in time. There should be an evaluation of these skills to answer and that's why it is so hard for me to give an opinion.

SC3: This question makes me think of something cultural. In our country, there's a lack of initiative to go to museums or science centers. There are few possibilities and spaces to do so, but the statement makes me think about a systematic visit. I imagine the different behavior you see in students in museums in Europe, USA compared to the museums here. They are very respectful and I think that it has to do, culturally, with their different preparation. Sadly, in our country many kids go to a museum for the first time when they come here, and they come once in a lifetime. So we cannot ask them to acquire abilities and then apply them if they come just once. I think this statement is out of our culture.

SC1: I think museum visits should be strengthened in order to develop abilities in the future.

SC2: Instead of spending money in the construction of labs in schools, science centers are the labs in this city, so schools should include visits to these places in their school planning.

CP1: There's a relationship that schools haven't taken advantage of: to assume that science centers are big labs that are there and they are a resource that I can use anytime I need to, anytime my teaching activities require that, even if that means to come 20, 40 or 4 times. If that makes sense along my educational history, then maybe the statement is true. This statement is very ambitious, I don't believe it. It would be great if it were true.

T1: To go to a science center just once is going to be good, the kid will never forget that but the details of that experience aren't going to remain. Visits should be systematic. What would be ideal for a teacher? To come with 10-15 students instead of a whole class of 50.

SC1: I have seen that sometimes these field trips are also for teachers, so they don't care if the kids learn or not. There's a need to give field trips an educational focus.

T1: And schools should take care of that, the principal.

CP1: Not only teachers do that, parents also show that behavior.

CP2: I think it's also a matter of resources... I think the teacher has to struggle before taking kids to a field trip. To struggle with the principal, with parents, with resources...

SC1: We plan a lot of activities for schools to go to, but teacher always prefer that activities go to their schools. It's easier for them that we go visit them instead of struggling with all the process.

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

SC2: Again, I think this statement is too ambitious, who does enough? How much is enough? What kind of creativity do we want to promote? A thousand questions arise from that statement. I think they do what they can and they do it brilliantly considering their resources. At the same time, it is never enough. It's very hard to enclose this, because I also know the board of directors of other science centers and they do not have any more resources, so what can they do? I think this statement is unfair because it sounds like it's their responsibility.

CP1: I think that, compared to others, there are science centers that do it. But in terms of contributing to a knowledge society it is complex, I don't think these concepts are developed. Maybe science centers promote this in an indirect way and contribute a little, but I can't think of a way for science centers to promote this kind of behavior. I think creativity isn't promoted in the speech, but in actions. And I am aware that when you give a kid too much freedom in front of an exhibition, it doesn't work. I think this statement sounds good as an ideal, but impractical.

SC1: I think it can be done, but I agree with you: there are science centers that are out-of-date and they are lacking other spaces to develop creativity, like workshops. Through this kind of activity, we can promote visitors participation in the scientific guidelines of the museum.

CP2: I think in Chile, museums do the extraordinary. With the resources they have, they do much more... maybe they don't totally achieve this goal, nobody does, but in our reality all science centers do extraor-di-nary efforts to do this.

SC2: Besides, we don't have public policies regarding these aspects (creativity, innovations and knowledge society). Out of the OECD ranking, Chile is second to last in the investment in science and technology. We are one of the countries with the fewest amount of scientists per capita, so why do we want to promote scien-tific vocations? There will be no place for them to work, there will be no funding, so we are holding science centers responsible for promoting careers that don't have much projection. I think science centers do their best in our reality.

CP1: The activities in science centers are also educative and are intended to spread science, not only expo-si-tive. Most museums in Chile are expositive, they show things. Very few create workshops and activities, or talk about the direct relationship that exists between a museum and a scientist.

CP2: Sadly, I think that is because there are little resources for science centers.

CP1: I disagree, it's not about money. We need to understand that this is one of the goals of a museum, and not just to expose. We need to bring science closer to kids and visitors.

SC1: And I think that's a very good way to teach, and there's a huge need of workshops and activities in sci-ence centers.

T1: MIM also has a program for teachers and that is great. It gave us tools that we can use and share with our students.

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

CP1: I agree.

SC3: I also agree.

SC2: Yes.

CP1: I think the ideal school is one that has 15 extracurricular activities besides classes, where students can experiment. The vocational work there is an endless discovery, to do science, to do art, literature, etc. Through this journey of discovery kids are going to discover what they are good at and what they are not good at, what they like and what they dislike. That journey of discovery is necessary, but it's also very ex-pen-sive. So that's why it is good that science centers exist, and other kind of museums. They are necessary be-cause they work as an extracurricular activity or laboratory that doesn't exist in the school.

T1: But we also need to have in mind that it can be done with simple materials, we don't need a super lab, we just need to have the disposition to experiment and good questions.

SC3: I think these skills can be developed in any extracurricular activity. I even think that you can develop these skills not necessarily by taking little kids to science centers or museums, but to the local playground, teaching them to respect public spaces, teaching them to share, to respect everyone's turn. If we taught toddlers all these soft skills with fewer resources, we could promote them so when they finish high school these skills are completely achieved.

SC1: But I think that also needs to be addressed by schools. There are parents that don't teach their kids any ability, so that's where the school gains a major role. Sadly, schools are not always open to develop these kinds of activities, because it means time, money, an investment from their part, but they don't see how beneficial this could be for their students.

CP1: It also has to do with a cross-curricular subject, both in terms of thinking and experience. I think schools are wrong when they separate different fields. For example, in a cooking workshop you can learn about everything, every field. Sadly, schools don't take advantage of that.

T1: Little kids do, at least during their first years of school, I've seen it.

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.

CP1: I think that statement is absolutely true, because schools are centered on quantitative indicators that reflect learning processes in children. Soft skills are very hard to measure, so most of the time they are not reflected on the quantitative indicators. Therefore, of course it takes time away from tested skills, because that's what instruments quantify. But I think that's a limitation of the measuring instruments we use. I don't think it is wrong to take time away from testes skills.

CP2: I disagree, because I think many of these soft skills are developed in parallel with "hard" skills. And if, when studying a "hard" skill, we dedicated more time to the soft skill, the "hard" skill would be promoted. I

think schools have many spaces that aren't taken advantage of, like breaks, lunch time, and the classroom dynamics. They should be supplementary material inside the formal contents.

CP3: I also disagree; I think we need to dedicate more time to things that are supplementary to another thing, which would probably promote much more the knowledge that an individual has.

SC3: I don't think the part of the statement that says "that's where science centers can play a role" fits. It's impossible to focus on the development of soft skills when we have a thousand visitors every day. If we believed we are able to do something like that, we would think of ourselves as superheroes. It's impossible; we could not do such thing. We can do our best effort to develop soft skills, but it would be too ambitious, it's not part of our mission. Maybe in other countries, in other museums where kids go and behave, and they go there every year, maybe then we could think of one of these skills being developed. And they would have to have many guided tours in this context.

CP2: I think soft skills are always bound to socialization. So the development of soft skills could only be pos-sible if you knew everyone in the museum.

SC3: Exactly, to do many group activities. But that's something else, it is not part of our role, it would be too ambitious.

T1: I was very glad to see a tourist with her two children and to see her helping them, explaining, teaching them, that's very beneficial. They can ask, they can give their opinion and can look around very calmly; very different from when a teacher comes with his entire class.

SC3: But I think it would be much easier for you if you could come with 10-15 kids. Then you could focus on developing these soft skills. Otherwise, it's impossible.

CP1: I need to clarify something... If kids come with their class, they act like criminals. But if the same kids come with their parents, they act completely different. And if the teacher goes with them, they act com-pletely different too.

T1: There are different kinds of schools, and I do not intend to discriminate anyone. There are different re-ali-ties.

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

SC2: This is a subjective statement; I would have to look at the statistics to say if I agree or not. I cannot give my opinion on something like this.

(The moderator emphasizes on their beliefs and opinions about the statement)

SC2: I think they have little impact, because the number of applications to science careers that I know unof-fi-cially is going down. And there are more science centers than they were 20 years ago, so if the number of applications to science careers is decreasing, science centers have little impact. Since it is not their mission, it's ok if they are not doing that. I agree.

CP1: I think this statement is reiterative regarding a previous statement. It said that science centers should not promote science careers, it's not their job. We discussed it then. They have much or less impact de-

pend-ing on many factors: what was the visit like? How inspired were the guides? I think there have to be a series of fortunate events for that to happen. If not, then it's not possible.

SC1: The key to generate that impact is to complement visits. An inspired guide generates an impact. A well done activity also generates impact. But the visit by itself doesn't.

SC2: Or a family worksheet: "What exhibitions did you visit today? So now take a match and do this experi-ment with it". And the visit would be strengthened, they could show this experiment to another kid that didn't go to the science center, and show him what they learnt.

T1: I see different perspectives. That a visit has an impact, it could have it. It would have to be more system-atic, more guided. But when the time comes to choose an area of study is another matter. Many times stu-dents have to worry about how much money they can make once they get out of college because they have to pay for their years of study. I think they are two separate things.

CP3: I think that all the young and not so young scientists that I know have always told me about the great experience they had at a science center and that means something. I'm not saying that's elemental in Chile, but it's a reality for all the scientists I know. They aren't so many, but anyways.

SC1: I know a scientist that became one because of his visits to a museum, because he participated in a pro-gram of scientist youth in the 80's, but that doesn't exist anymore. There's no room for the scientist of a museum to explain his/her experience as a scientist. I think there's a need to amaze people showing them that point of view.

T1: When grownups have that opportunity, they are amazed by that and they want to become a scientist. I can see it with 11th and 12th graders.

CP2: I think that kind of experiences at least give you another possibility of making a living out of science. Many people don't even know that science careers are a real possibility, that they exist. And to talk about science careers we would also have to talk about the reality of universities in Chile that is another parallel phenomenon that we can't elude. The fact that students get out of college to make money has a direct rela-tionship with people not pursuing science careers, because they are not very profitable. And it is also very hard for scientists to finance their own studies or projects, which is the opposite for designers, publicists, etc.

SC1: There are funds for that, but you have to invest in education, so you need a doctorate degree, publica-tions, etc.

CP1: Anyways, I think there's an interesting role in terms of demystifying science and scientific activity. Sci-ence centers show a component of possibility in the life of the child that visits them. He or she could eventu-ally be a scientist, or maybe not if he or she likes something better. But showing a science career as a possi-bility is a great progress.

SC3: I think it also has to do with something cultural. Maybe you really want to study but this country doesn't give you the opportunity to do it. If we were in countries where education is free and there's no selection it would be different, because if you want to study you just go ahead and do it. Here there are many young people that want to study, they have a vocation, the abilities but they can't study.

SC2: They don't have the test scores they need or they don't have the money to do it.

CP3: But going back to the statement, I think that if you don't have the opportunity to see that there are

people that actually dedicate their lives to science, it's very hard for the kids to see this career as a possi-bil-ity, and I think museums and science centers actually play a role there.

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

SC3: In our case I think the statement could be true, because with one visit, once in a lifetime, we cannot be so arrogant to say that we had a long term impact on that person. I think it needs to be something systemat-ic.

SC1: I think MIM leaves an important footprint in children. When you talk about a subject you show kids how it works with specific experiments, so you are investing in their learning process.

SC3: Yes, but in the long term. Is that a long term impact? How do we know what's going to happen in the long term? Maybe if an adolescent comes, the visit will have more impact because he/she is going to re-member more of it, but when we talk about a 1st grader, 2nd grader, if he/she comes just once...

CP2: I think it can have an impact from the imaginary point of view since you can recall experiences kids have had at a science center, and they can be a resource in this sense. That would require systematic visits in order for the visitors to remember all the details, to have a long term impact.

CP1: Exactly, maybe it doesn't depend on the science center. It depends on a tacit or explicit coordination between the examples they have seen in the science center. Or understanding that the next visit to the sci-ence center is going to give examples of a concept that I am trying to explain, that is very complex...

SC3: Probably the same thing happens to you (to SC2). When we go to a city with an itinerant exhibition people always ask us "when will you be back?" and that's very hard for us, because it is very unlikely that you'll be back. You want everybody to know your science center, so you go from one place to another, to another, to another. When you come back after 4 years there's a whole new generation, so can we talk about long term impact? I don't know.

SC2: I think we have an impact in emotional terms and that leaves a mark. A headmaster of a school that our bus visited said that before going there, all kids wanted to be seasonal workers and now they want to be doctors and they are not going to forget that. Maybe we didn't stimulate scientific vocation, but he said "Thank you for making them dream" and that happens here too. I think the emotional part can have a long term impact, because the kid was in a lab, in a science center for a day and had a chance to know a whole new world that didn't exist for him/her before. So that can have an impact, but it's hard to measure. Just like soft skills. I think that's the role of science centers, to generate different sensations, a memory of a moment when you could open yourself to different possibilities.

SC1: I think that's a key element: sensations, to amaze. That lasts forever. Those are things that science cen-ters have to appeal to.

SC2: That's why I think science centers have to empower themselves and believe they have a long term im-pact. They could open more doors to activities outside of the science center.

SC1: And also to promote viewing these spaces as a complement for teachers.

CP1: I would also include parents in this matter, because they are the main mediators.

Everybody: Yes, of course.

4 Colombia

1. National Policy on STEM Education and the Role of informal learning in Science Centers

1.1. Brief description of stem-education in Colombia

Colombia is a Latin American country with 48 million habitants with an upper-middle income and a rich human, cultural and biological diversity. Despite of it has been in an internal conflict for more than four decades, it´s one of the most stable democracies and economies in the region. The country has a growing economy – faster than the Latin American average - mostly based in the production of commodities such as oil, coal, other minerals and different kinds of agricultural products such as coffee and flowers. In recent years, the country has been a focal point for international corporate investments and the services industry is growing.

Historically the government of Colombia has recognized education as one of the pillars of the construction of the nation. The National Constitution of 1991 defined education as a public service that has a "social function, through this seeks access to knowledge, science, technology and other goods and values of culture". STEM education is one of the most important components of the National Plan of Education 2006 -2016; the goal is to develop critical thinking and innovation skills for a sustainable human development. Under these agreements, the country has developed different policies, documents of reference – such as National Standards for Education- and strategies of strengthening and assessment for schools and teachers in order to improve the quality standards of education all around the country.

Nevertheless, national and local policies have not been as effective as they promise to be, because of the complexity of the challenges that the educational system faces. The most relevant difficulties are the big gaps in quality between rural and urban education, public and private schools, insufficient infrastructure and low standards of education of teachers. At this moment the illiteracy rate is around 5,8% (National Department of Statistics, 2012) - Mostly present in rural communities -.

Basic education (K-9) is an official right of children guaranteed by the government, but middle education covers only 76% of graduates from basic education (National Ministery of Education, 2012) and access to higher education covers about 30% of this population (National Ministery of Education,2012).

The country has a National System of Assessment for basic education since 1968, which is key to direct public policies. The national government has also decided to participate in international tests such as PISA[67] and LLECE[68]. Participation in PISA – since 2009 – has reported low performances even compared with similar countries in Latin America. Between 65 countries, Colombia ranked 61 in maths, 58 in science and 55 in reading in 2012.

	MATH	SCIENCE	READING
2006	370	388	385
2009	381	402	413
2012	376	399	403

Graphic 1 - The Average PISA 2006, 2009 & 2012 Colombian Scores. Source: Barrera, Maldonado, Rodriguez, 2012, Pisa 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Vol IV) Ch.4

The results are challenging for public policies taking in account not only the low performances, but also the differences observed between public and private schools. In terms of gender there are also important differences, boys tend to rank better in math and science while girls perform better in reading. Regarding to that situation, currently the National Minister of Education as well as some local Secretaries of Education are investing in programs devoted to improve the quality of education in general, but specially focused on math and reading. Professional development for teachers as well as extension of schooling time for kids are the main strategies in execution.

Higher education & research

As mentioned before, access to higher education is restricted to a small part of the population and dropout goes from 44.9% in professional careers to 62% in technical and technological levels. Regarding to STEM, only 1.6% of graduates are from Math and Natural Sciences, 16.3% are from social sciences, 22.7% are from Engineering (this data includes architecture and urban planning), 7.5% are from Health sciences and 2.1% from Agronomy and related areas.

[67] Programme for International Student Assessment

[68] Latin American Laboratory of Assesment of the Quality of Education (Laboratorio Latinoamericano de Evaluación de la Calidad de la Edu-cación)

FIELD OF KNOWLEDGE	2001	PART %	2013	PART %
AGRONOMY, VETERINARY AND RELATED	1.772	1.3 %	7.322	2.1 %
HEALTH SCIENCES	13.108	9.5 %	25.901	7.5 %
ENGINEERING, ARCHITECTURE, URBAN PLANNING AND RELATED	30.759	22.2 %	78.349	22.7 %
MATHEMATICS AND NATURAL SCIENCES	1.254	0.9%	5.538	1.6 %
ECONOMY, ADMINISTRATION, ACCOUNTING AND RELATED	44.008	31.7%	125.819	36.5 %
SOCIAL AND HUMAN SCIENCES	18.666	13.5%	56.181	16.3 %
EDUCATION	25.234	18.2%	34.528	10 %
FINE ARTS	3.867	2.8%	10.837	3.1 %
UNCLASSIFIED	0	0 %	615	0.2 %
TOTAL	138.668	100 %	345.090	100 %

Graphic 2 - Graduates for Field of knowledge, Ministerio de Education Nacional (MEN), Observatorio Laboral para la Educacion (OLE)

Despite of that situation the rank of graduates has increased in the last decade, today the number of graduates doubles the one of 2003.

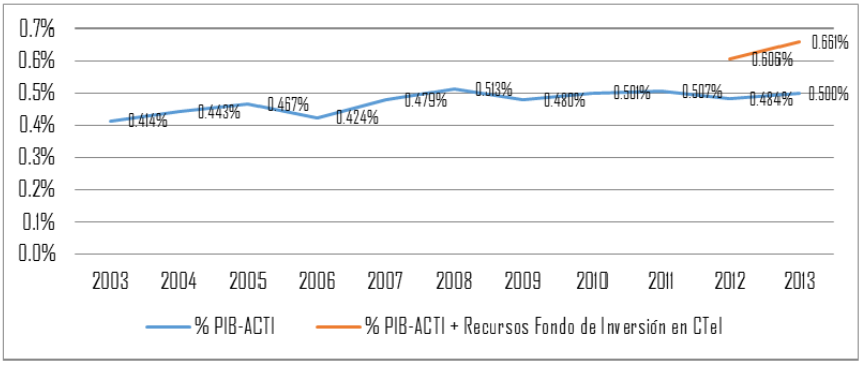
Nivel de formación / Level	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Técnica profesional[1] / Technical	5.185	5.179	5.439	8.672	10.36 6	15.002	19.429	19.837	18.798	21.450	**129.357**
Tecnológica[1] / Technological	18.692	17.992	16.036	16.205	21.231	22.835	25.326	24.695	76.176	81.169	**320.357**
Pregrado universitario /Bachelor (B.A. - B.Sc.)	98.514	97.754	91.964	91.024	103.761	111.713	117.281	120.721	130.199	138.430	**1.101.361**
Especialización / Diploma	21.332	23.099	23.815	27.284	34.957	41.565	43.620	55.604	61.284	60.048	**392.608**
Maestría / Master's degree	1.848	2.281	2.464	3.287	3.490	4.141	4.803	5.932	7.035	8.822	**44.103**
Doctorado / PhD	46	50	48	91	94	139	173	211	268	310	**1.430**
Total graduados / Total graduates	**145.617**	**146.355**	**139.766**	**146.563**	**173.899**	**195.395**	**210.632**	**227.000**	**293.760**	**310.229**	**1.989.216**

Graphic 3. Higher education graduation, 2003-2012. Ministerio de Educación Nacional (MEN), Observatorio Laboral para la Educación (OLE)

It is important also to see that post-graduate results are increasing faster than bachelor education, 35% of PhD graduates are from Natural Sciences. In terms of gender it is noticeable than for bachelor programs 55.3% of graduates are women, but this average decreases to 30.6% in PhD studies.

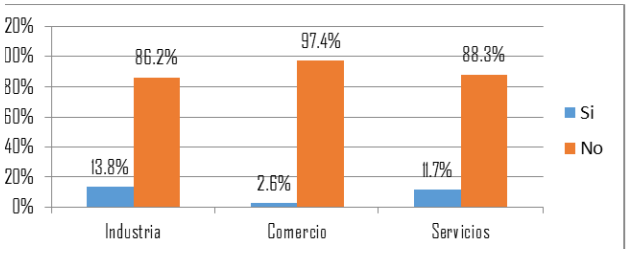
Despite of the increment in post-graduation results, Colombia only has 1.84 active researchers per 1.000 habitants, which is very low even for the Latin American average of 5.83 per 1.000. Women are 34.8% of the total, and only 26.9% of the STEM field.

Investment in science and technology has been historically low, it has ranked around 0.4% of the national GDP, nevertheless has been increasing and today represents 0.66% of the GDP given to a national law that increased the average of governmental investment.



Graphic 4. Investment in Science and Technology as % from the GDP.

It is important to say that most of the investment is done by government agencies; private industry has very low investment in R&D, as can be seen in the next graphic that illustrates the number on enterprises that have a department of R&D.



Graphic 5.Enterpises (Industry, Commerce & Services) with R&D Department. DANE, Departamento Administrativo Nacional de Estadistica. Boletin informativo, Encuesta de Capital Humano 2012

1.2. ROLE THAT SCIENCE CENTRES PLAY IN STEM-EDUCATION.

Colombia has different kinds of science museums and a few science centres, many of them were born in universities as scientific collections, and its origins can be traced from the XIX century. In the 1930´s some University Museums were born, but its accessibility is still restricted to a small part of the population, mostly university students from science careers. In the 1950s and 1960s several initiatives from civil societies started the creation of botanical gardens and zoos. That is the case of the Botanical Garden in Bogotá opened in 1955 and in 1967 the local government started the construction of the Planetarium of Bogotá, which in its origins also hosted a Natural History Museum. In 1984 the first interactive science exhibit hall was created in the National University of Colombia – The Science and Play Museum – which is still open and leads a network of small museums in the country, and in 1987 was created the Chlidren´s Museum in Bogotá.

In the 1980s and 1990s a movement to increase science literacy in Colombian population promoted by Colciencias -the national authority of Sci-Tech – and the Colombian Association for the Advancement of Science purposed the creation of Science Centers as a strategy to achieve that goal of increase what was named as "social appropriation of science & technology". That movement is the origin of Maloka, the first interactive science center of big size in Colombia, located in Bogotá, the capital of the country in 1998. Since that time several small science museums or science exhibitions has been created in some cities.

It is notable that in Medellín the second city of the country two interactive Museums have opened doors in less than 10 years, one of those Parque Explora, besides the interactive collection, includes also an aquarium and a planetarium, holding the biggest facility in the country. During this decade several projects of new museums are in progress. Nevertheless only 5% of the museum institutions in the country are museums of science and 20% of the population has visited them at least once in their lives while 40% has visited zoos and aquariums.

Science centers and museums are mostly visited through school trips, but they also receive families during the weekends. Some of them have programs of professional development for teachers or afterschool programs such as science and technology clubs or thematic workshops. In general, it is an emergent industry in the country with many possibilities to extend its impact.

1.3. SOME EXAMPLES OF EXISTING SCIENCE CENTERS

Taking in account that the study has been done in Bogotá, the capital city with almost seven million habitants, three different scenarios of this city will be described:

1.1. Planetarium of Bogotá: It was one of the first public initiatives of science communication in Bogotá, opened in 1967, it was planned as a cultural center devoted to different areas including arts and natural history, because of that, Astronomy activities lost its visibility with the time until almost disappear. Finally, in 2013 a reopening with a complete renewal of the space, including an interactive exhibit hall, new projector for the dome and telescopes, as well as the decision of the Secretary of Culture of the city, to focus this scenario only in Astronomy and sciences related to it has given new life to the Planetarium. Today it focuses on attending scholar field trips, and offers workshops and science clubs for boys and girls.

1.2. Children´s Museum: Opened since 1987, the children´s museum was the second one of this kind in Latin America after Caracas (1982). It is a private initiative from corporate partners joined in a non-profit foundation. It is a hands-on museum devoted to science, technology, culture and arts. Its facilities are 8.000 m2 and offers sci-tech workshops, computer science activities and traveling exhibitions. The Museum receives 150.000 visitors per year 69% of them are boys and girls under 11 years old.

1.3. Maloka: Located in the most important project of urban development of the city, Maloka opened its doors in 1998. It is a private non-profit organization, promoted by the Colombian Association for the Advancement of Science, Colciencias, and the Major´s office of the City, sponsored by several private and public organizations,

but only for the construction of the facilities, not for operational funding. Maloka is the first science center of big size in the country, it receives an average of 350.000 visitors per year – school field trips and families - and its facilities have 17.000m2 including a big open plaza. It has nine exhibit halls in different areas of sci-tech, a cinedome, a 3D theater and a diverse offer of activities for different audiences, such as science clubs, scientific agenda (lectures, science carnival, workshops and science-theater). The program "Maloka without borders", offers different traveling exhibitions that move all around the country and has also science clubs working in different parts of Colombia.

2. OUTCOMES OF THE FOCUS GROUPS

2.1. Introduction

To conduct the study, two focus groups were done in February 2015 on the facilities of Maloka Science Center. The first one, in February the 4th was devoted to collect information from the schools, 10 people coming from public and private institutions attended. It was a heterogeneous group: six women, four men, seven people were teachers from natural sciences, social sciences and technology, one was Principal of a public school, one academic coordinator and the last one was counsellor of a public school.

In the second focus group held in February the 18th were invited science communicators and representatives from industries, they were invited through e-mails sent to a data base of approximately 35 people, phone calls were done to confirm attendance. Even though eight people confirmed to come, only three attended, each one came from a different science museum: the coordinator of operations of the Planetarium, the coordinator of education of the Natural History Museum at the National University and the Director of operations of Maloka.

Both focal groups followed strictly the protocol suggested, starting by a presentation of the project and the partners working on it. The English presentation was translated into Spanish and used as a guide to follow the protocol. In the group of teachers, it was necessary to explain in deep the nature of the OCDE, as well as the intention of Colombia to become a member, because they only had the reference of this organization for the PISA test.

2.2. The eleven statements

2.2.1. We should let children just enjoy science centers, not turn centers into schools

Participants think that science centers should preserve their playful character.

"I personally think this is a recreational environment for them away from school space that is off the routine". Even though its playful nature, they think visiting science centers is a learning experience: "I agree that you should not turn science centers into schools and anyway they are always going to have learning".

Teachers think that learning in science centers is not restricted to science and can go beyond: "(...) Is that children and young people not only learn concepts, they also relate with each other (...) these centers provide insight into other cultures, recognize other people, other people different to those in the classroom or on the desk ".

However, in both focus groups, participants discussed relationships between Science centers and schools, and expressed different positions. A Teacher expects that the science center "supports and provides tools to supplement classroom training for the kid. Therefore I believe that should not become schools but generate strategies aligned with the school where strengthening competences provided there". Nevertheless, teachers and representatives from Science centers defend the freedom that children should have to explore these spaces:

"I think it's important to let children enjoy science centers, because for a child to learn naturally scientific knowledge, I think one way for them is to learn much more playful (...) recognize (the museum) as a space where you can learn some scientific concepts without being as "square" as it is done in school"

Representatives of science centers, also discuss about the relationships between playfulness and learning: "It should be clear "(...) when the enjoyment facilitates learning and what the rules of science centers are. And what are their gauges. "

2.2.2. Science centers work better for boys than for girls

At the beginning of the discussion, teachers and representatives of science centers said that experience with science is not distinguished by gender. "There is nothing that experience dictates that.", "I have worked in science for several years now and actually at least in school boys and girls approach in a similar way to science because it is the natural environment they are exploring."

However, deepening into the discussion, teachers and representatives of science centers, spoke about different dynamics that, although not originated in gender, have influence in the way children relate to science centers: "I do think that boys and girls have motivations that may be different but not better or worse". Those motivations, according to a teacher are expressed in the performance of children: "(...) kids are very good to work with technology but the girls to communicate it, excellent."

Although the biggest difference is perceived in terms of age when one observes that interests change.

"An activity that in some moment can call the attention of a girl to 5, 6, 7, 8 years old girls, (after that) by their age, it doesn´t capture their attention. They do it just to fulfil a commitment. But in these scenarios where they are free (...) the boy enjoys much more. I think the word best fits into the idea is that the boy extroverts here in this type of facility. And there are a number of girls that also do very well, but also are girls who come to talk to chat, have other spaces of communication. "

2.2.3. Schools can learn more about teaching science from science centers than the other way round.

Although there is no unanimity on the position, participants in focus groups emphasized the increased capacity that feature science centers for innovation in teaching methods, so most recognized a greater influence of science centers in schools than other way round: "I think the school pedagogy is reduced to two resources: reading and writing. That historically framed school, and then you can learn from the science center the multimodality, diverse modalities (...) ".

Likewise, although representatives of science centers think that what they offer should be linked to school activities; they recognize that there is not a systematic work to know more about them. "I have seen that these centers are specialized... we try to go deeper in some topics than it is done in schools, and we don´t have a direct approach to schools...they (schools) are who come to us"

In the other hand, some participants think that the origin, mission and conceptualization of science centers has born from the necessities of the school and that pedagogical background of science centers has been borrowed from reflections about education in school.

"(...) Learning must be reciprocal because science centers should support the school to define content. They have to see what the contents of the school are to see what the centers of interest and experiments are in order to reach a more effective and accurate way of learning for the student. "

"I think more than schools learning from centers, the centers provide to the schools with a space to practice. Because we have all the pedagogical knowledge, we can give them (students) all the tools but do not have the resources to identify exactly how this environment can be "

A representative of science centers expressed that, in fact, is the formal education that has constructed a systematic body of scientific knowledge: "As a body of knowledge ... be it papers, texts, theories, practices or whatever, there is much more in the field of formal education than in interactive centers (...) The interactive centers are feeding from this knowledge (...) ". But she stressed that today science centers have a comparative advantage over schools with regard to the construction of pedagogical knowledge as there is a greater freedom and ability to experience methods, strategies, and learning dynamics: "(...) Science centers have the right to be wrong and can rehearse and play trial and error without anything happening, they can do it and can capitalize on that trial and error".

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

Contrary to the initial phrase, participating teachers reported that promote scientific careers should be, in fact, a mission of science centers. Science centers "should promote scientific careers (...) because schools are as much immersed in certain structures or certain methods, while science centers have a more open mind and can innovate according to what they already know and to the knowledge of young people themselves. ". Representatives of science centers are more skeptical about the extent of these spaces as for career guidance: "I would think not promote. What one seeks is to spread and provide the information and generate interest. (...) It (promotion) sounds to me as much publicity thing ... is not the goal that one seeks."

2.2.5. Science centers rarely focus on the relationship between science and industry

According to teachers some science centers allow or have connections with some industries. In this sense, they give examples of exhibits that have been made in science centers with local industries. However, it is recognized that the relationship between industry and science centers, has been little explored and has great potential: "I think it is incidental (the relationship). It's not an influence in which you have an intention, but could become a key strength of science centers. It could be a strong point of science centers but now is not strong enough. " This disconnection is even more evident

for representatives of science centers, which is seen as problematic: "The industry has been a bit far from the center, ...(there is) not proximity between industry and the science center ... I think that it should exist".

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

Although teachers stress that usually visits are limited, these give young people skills that transcend the scientific aspect and involves another way of relating and thinking their environment: "Yes, I think that, in terms of soft skills of problem solving they take more to home, about teamwork skills also (they) take much more about their life after school. Even they begin to rethink things they have in their home and in their environment. " Another teacher expresses that science centers are rich environments to promote learning "I think (they learn) many skills of science centers only the fact that they see symbols,(helps them to) learn about other languages (...)".

Unlike teachers, representatives of SC are skeptical about the impact it can have on youth a visit so short. They emphasize also that such skills can be learned in other spaces: "It's that the skills you learn here are not unique for science centers. Not when we're talking about those soft (skills), (youngsters) acquire them at home ". Even thought, they express that longer exposition to science center experiences can support in a deeper way the development of soft skills.

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

Teachers point out that the shortness of the visit, it is difficult to think that "promotes" creativity, as this depends on a process that ideally should be guided by the school:

"(...) Skills, knowledge, and all this about creativity are not affordable processes in one visit ... perhaps it motivates or promotes the interest the student. But if a long or middle term process is wanted, that would be a process, a workshop, something much more structured and longer".

Representatives of SC agree with that position, they said that this kind of learning can occur "if you have a process (longer than a visit), or that skills development can occur in science clubs, but if we are speaking about a kid in a regular visit ...in that case, yes I doubt it"

2.2.8. 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.

Regarding to soft skills the teachers said them can be learned in other spaces both inside and outside the classroom, in fact, for some teachers the soft skills can be best learned in other areas outside education or science:

"(...) Many times you become so immersed in science, (that) many of these social skills are not developed because you are absorbed with your knowledge, with your experiment, that does not allow you to interact much with the other, while in a game is mandatory, in the arts is the same (...) ".

Nevertheless, for some teachers, if a science center is conceived socially and culturally situated, may be useful to learn this other skills:

"I think those skills, although are natural, it depends on how are culturally seen and they are enhanced in one way or another... I think the issue of communication, for example, our kids, because of our cultural history they are from an oral tradition, so for them to explain a scientific phenomenon from orality is easy "

SC representatives agree that those are skills that can be learned in different environments than science centers. However, it is emphasized that science centers promote some characteristics that are not so easy to learn in other contexts:

"(...) When you begin to learn about creativity and conflict resolution (the school) provides a variety of tools, which are a more social tools. Those that have to do with science are a logical tools, about logical thinking, referred to a totally different way to address the problems. "

2.2.9. 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.

Regarding to this issue, teachers have different opinions, showing that there are some inconsistencies in discourses and policies about the objectives of education.

On one hand, teachers emphasize that the development of soft skills plays a central role in current international and national guidelines that speak about the role and goal of education:

In "(...) UNESCO documents, when they refer to science education from school there is not said that it is to become scientist or to learn the whole method, but simply to learn to be a person capable to live with the

other in a world that changes all the time. "

However, "(..) Are often the managers (principals) who believe that focus on such skills will worsen the test results. Then they focus on the evaluation results, the percentage, to meet a number of requirements. "

That position ignores that soft skills articulated inside an interdisciplinary learning, might permit that "(...) knowledge be more natural and reaches in a more playful way".

However, the teachers also indicate their responsibility in the fact that in school learning soft skills is neglected: "I think sometimes we as teachers have no training, do not know how to approach many situations (...)" ; "(...) It´s also a lack of time for dialogue among teachers because one realizes that informal spaces (...) from the dialogue of teachers can help develop those skills"; fatigue is also mentioned, among other reasons that influence the development of soft skills as something neglected in schools.

With respect to science centers there are several consequences related to these contradictory positions on soft skills. On the one hand, point out that science centers are places where you educate through the development of soft skills, so "(...) the school has been enriched with all interactive centers and it would help to enrich the competences".

"Centers can play a role? ... Of course, to the extent that we are helping in the processes that they can reach in schools and can change a lot the way of thinking in the academic context that has the school looking at the needs of children ".

Likewise, teachers said that under the pressure from some managers over the time that can be used for learning soft skills, science centers become in unique spaces where students can access this type of knowledge:

"So that's where the science center can play a key role as we can increase the exposure time, other two visits, work on the website, give proposals in the work done in schools when there are fairs or events ".

However, from a diametrically different reading, according to the perception of teachers, for some managers fieldtrips to science centers may be counterproductive in the search for better test results, as judged as downtime in teaching.

Representatives of science centers are divided. On one hand, it is considered that the time and the visits are so limited that it is unlikely to assume that science centers have a positive or negative impact. A second opinion is that while soft skills are not considered among quality measurements, the time spent on its development is counterproductive to achieving the objectives set in education policy. The third point of view, and so close to the exposed by teachers is that "science centers can contribute to the development of skills (...)", off course, depending on the possibility to formulate a methodology that can take the most of the short time of visit.

2.2.10. Visiting a science center has little impact on whether students follow careers in STEM.

For teachers visiting a science center.

"(...) Has a high impact depending on age. Let's say that very young children, who come to a center like Maloka go out wanting to be scientists and go out of a science center as Bioparque wanting to engage in the study of birds. So that from little ones there is an interest and motivation and must be given as a starting point ".

But this interest fades with time, so that stress the importance of making more frequent visits of youth at the end of the primary cycle of education:

"So it is important those visits for children, bringing them to the sciences centers so they have a greater opportunity. So that impact is like a possibility of opening a little focus on "what I want" "

In the case of the representatives of the SC, one participant noted that, although he doesn´t know if there are studies that can test the impact of the SC regarding to vocational guidance of young people, this influence can be seen in the case of long-term activities that are part the offer of science centers He explicitly refers to workshops and science clubs, and not to the occasional visit.

Another focus group participant differs, highlighting how even in sporadic visits some young people seek for information on aspects such as "income, or the kind of opportunities or the labor field for careers in biology," -the topic of the museum she represents-.

Finally, although he considers that the percentage of children and young people who, after a visit to science centers, decide to engage in STEM professions should be low, the third focus group participant also stated that "If there were no science centers I think many would not dare to study science. "

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

Regarding to this statement, the perception of some teachers is that high long term impact of science centers is not as big as it could be because visiting it is

something sporadic in our context. It relies on the difficulties inside the schools to plan and execute a field trip (especially for financial reasons), as well as because of the lack of awareness of teachers regarding to the benefits of visiting a science center.

Yet another teacher says that even an occasional visit can have a long term impact on young people coming out of basic education, because the science center visit may give them "(...) the opportunity to see these expectations of life". Also, another teacher emphasized that a long-term impact can be achieved if the visit is linked to strategic planning for extending the experience and make it useful in classroom work.

Representatives of science centers on one hand, indicate that there is a large investment in science centers, "I believe that there is investment in processes... you can strategize where there is a financial investment for the development of the strategy (...) ", but it is highlighted the doubt about what could be the long term impact on youth regarding to the processes of learning.

Another participant remarked that the activities and their development in the science center can influence its impact among participants:

"(...) To deepen into the thematic or the use of other tools, and what I see is that the attitude of the guys is completely different when the tour is done alone (...) compared to when we take the time, go deepen and the boys go out more grateful and more interested. "

Finally, it is also highlighted that the impact of visits to the centers may be of longer term for young people who, for economic reasons, have less chance of contact with this type of environment.

3. CONCLUSIONS

According to the outcomes of the focus groups following we present main conclusions:

3.1. Conclusions per statement

3.1.1. We should let children just enjoy science centers, not turn centers into schools.

It seems to be an agreement about the playful character of science centers as something relevant in the experience of learning. Nevertheless there are two different positions about its relationship with school, one more focused on the understanding of science centers as exploration experiences that mainly inspire and motivate, versus a point of view that emphasizes in the necessity of a thoughtful connection among field trips to museums and classroom activities.

3.1.2. . Science centers work better for boys than for girls

For the interviewees there is no difference in the dynamics that occur in the center according to gender. This is because, neither objects nor activities have been developed from a discriminatory attitude or that will better serve boys or girls. However, participants in the groups observe differences in the likes, according to the age of the children; at younger age, the interest that children have in science centers is similar, but, through adolescence, differences are seen in the way that youngsters explore and express their interest in science.

3.1.3. Schools can learn more about teaching science from science centers than the other way round.

Despite of recognizing that initially science centers originated in accordance with the needs of the school, and making use of pedagogical and scientific information produced within formal education, today science centers can be a source of information and innovation for schools.

As mentioned by some participants, the flexibility of the centers of science and its ability to propose in short periods of time new pedagogical strategies has led to innovations that can be very attractive and useful in schools. Flexibility lacking in formal education institutions because of norms and educational requirements limits the proactive capacity of teachers.

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

While for teachers, the rationale for science centers is precisely to provide new career prospects for young people, for representatives of science centers there are few chances of having long term effects in youth decision making. This is due to the short time of a visit and to the fact that these are rather sporadic, but considering activities involving regular visits and learning processes - science clubs, after school programs, etc - may have a higher incidence in areas such as career guidance for young visitors.

3.1.5. Science centers rarely focus on the relationship between science and industry.

For most teachers, as well as representatives of science centers, there are not strong bridges between industry and science centers; this kind of union is considered as having great potential for the development of other forms of non-formal education.

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

Teachers have observed that despite of the short time students stay at science centers, they learn not only about scientific concepts, but also other ways of relating and thinking the environment. Representatives of science centers are more skeptical about the long-term incidence of sporadic visits by most people visiting science centers, however they nuance this observation noting that don´t know studies to support or refute the initial statement.

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

Regarding to creativity, both teachers and representatives of science centers, say that its promotion and development is an educational long term process, they see difficult to achieve in the short time of a visit. From this perspective, the school or activities such as science clubs and afterschool programs are better able to develop creativity.

3.1.8. 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

With regard to soft skills both teachers and representatives of science centers have noted that there are other curricular areas in which you can learn them. They even recognize that activities such as sport or art may be more conducive for learning soft skills, but point out that science centers and science in general, can teach various soft skills important for life such as those related to problem solving and logical thinking.

3.1.9. 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 focus group with teachers revealed that, at this moment, there is a struggle between the various actors in the educational system around the issue of development of soft skills. While teaching and developing soft skills is considered one of the objectives to be achieved through education, quality guidelines currently promote teaching concepts as the priority of schools and the time teachers spend in the development of social aspects of the child is undervalued.

From this reading, science centers are seen as spaces that can fill this gap in educational institutions around the soft skills, but it is important to be aware that for some managers and other decision makers in schools, field trips could be considered superfluous and a waste of time.

3.1.10. Visiting a science center has little impact on whether students follow careers in STEM.

According to teachers and SC representatives, vocational stimulation on STEM career can be done in science centers if there is a continuous experience and specially oriented for middle and high school students.

Nevertheless, for some teachers visiting a science center may have long-term impact with regard to career decision making even in younger children in sporadic visits, especially those coming from communities with fewer opportunities.

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

Regarding to long-term impacts of science centers, teachers point out the various obstacles and difficulties for schools to have a permanent relationship with science centers (economic, bureaucratic, lack of awareness about the possibilities of science centers), so impact in many cases is reduced to the possibilities that one single visit can offer to the students coming.

For representatives of science centers, the institutions they represent have invested, time, money and human resources to improve learning opportunities offered to their audiences. Although it is noted that to have a big impact it is necessary to develop an educational process both within the museum and outside of it, they recognize that in fact there is an impact with the visit to a science center.

3.2. Conclusions on the Role of Science centres in the acquisition of soft skills

Science centers provide playful educational experiences that go beyond the understanding of science, stimulating in boys and girls the development of soft skills related to the nature of science such as critical and logical thinking, problem solving and communication. Nevertheless, it

is perceived that one sporadic visit is not enough to complement the process that schools have to develop. Visiting the museum several times during the school cycle, as well as to create different kinds of experiences, including long lasting activities such as science clubs and afterschool programs is important for science centers to play a more visible role in the development of soft skills in youth.

3.3. Advantages of informal learning in science centres and museums

Science centers are perceived as playful and learning environments that give students the opportunity to acquire scientific knowledge in a fun way, implementing the systematic knowledge of formal education and relate differently to their environment fostering highly beneficial life skills related with the development of soft skills.

One of the advantages of SC compared to the formal education is that science centers are more likely to innovate in educational methods that school and have flexibility to decide about contents and pedagogical approaches. Pedagogical innovation is perceived difficult to do in schools because of restrictions in curriculum design oriented to perform well in national and international assessments.

Teachers perceive that one important aspect of the mission of science centers is to promote scientific careers. Regarding to the impact that science centers have in choosing careers in STEM a distinction is made by age. Although for younger people the visit causes much impact on the projection that they do about what they want to be, interest is diluted over time so it is believed important to visit again at the end of the primary cycle.

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

The expectation around science centers is to be constituted as spaces that complement classroom training for which a communication path between formal and informal education is proposed to generate experiences linked to the dynamics of the school without limiting the flexibility and the opportunity of free exploration during the visit. It is thought that science centers can contribute to the development of soft skills if a proficient methodology that can make the most of the short time of visit is made.

In both cases, the possible impact of SC experience in the future STEM career choices and the development of soft skills, it is identified the need to generate learning processes with a real impact in the long term. Specifically listed as positive experiences already working are afterschool programs and science clubs.

Relations between science centers and industry are little used and according to participants in focus groups they have a lot of potential so a challenge to assume for science centers is to strengthening these relationships.

Although educators and representatives of science unanimously found that children approach similar to the science way, they identified a decline in interest in the content of these centers in girls by age. It would be interesting to investigate the perception that girls have about science and technology an about science centers in order to improve the experience offered to them.

There are some barriers for schools to visit science centers, some of them are related to economic conditions of students, and some of them have to do with the orientation of school managers about the need to be focused in curriculum, which feeds the perception of field trips as a waste of time.

4. RECOMMENDATIONS

Science centers are seen as playful and innovative spaces that can be a powerful complement for schools in the development of soft skills. Although, in order to have a big impact in this issue, it is necessary to remove some barriers that neglect the possibility for schools and students to maintain a permanent and fluent relationship with science centers. Those obstacles are mainly economical and bureaucratic, and can overcome through the development of public policies that foster non-formal and informal education as something valuable to complement learning process of children.

It is also recommended the design of strategies for museums to have a closer relationship with teachers and managers of schools in order to promote a perception of science centers as valuable experiences that complement curriculum activities and provide a different approach to learning that might help to improve the performance of teachers and students.

Regarding to relationships with industries, it is necessary to strengthening ties that would support science center activities in the design of new educational experiences oriented to inspire and engage youth in STEM careers, as well as in soft skills development. It could be also a possibility to help students from underserved communities to visit to the museum.

Promotion of STEM careers is something that requires a constant process of learning through engaging expe-

riences for boys and girls, so following the perception of participants, it is important for science centers to develop long lasting programs that could be followed through time.

In terms of gender differences, there is not enough information, that could help science centers and schools to shape a more adequate kind of experience that would encourage both, girls and boys to be more involved in science and pursue STEM careers. It is highly recommended to foster research in these issues.

Finally, science centers are scenarios with a great potential to foster innovation in and out of school, especially in the development of soft skills, the flexibility and richness of the experiences provided by science centers is a great asset that communities have, nevertheless there is still a path of research and learning to follow in this issue. In this order of ideas, it is key to promote cooperation projects of research and innovation that would help the field as a whole to improve its impact in this direction.

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Summary

In figure 1, a summary of the opinions articulated in relation to the 11 statements, is presented. To the right is shown opinions condensed in sentences, which sum up the discussed topics. It is attempted to use the respondents' own words in the condensed topics. The figure is based on focus group discussions. There is a risk that some articulations or angels from these focus groups are not represented in the report, as the subjective selection of data limits the size of the report. In section 4 the origin of the topics are elaborated.

Statement	**Articulated subjects (summarized and edited by the authors)**
1. We should let children just enjoy science centers (SCs), not turn centers into schools.	Learning is an important element at SCs, as well as in schools, but it is important that the way of learning in SCs is playing and free - not traditional blackboard teaching. You can learn something at SCs without noticing it - the free environment can enhance learning. SCs are not amusement parks SCs can create wonder and motivate learning in the school.

2. Science centers work better for boys than for girls.	SCs are not perceived as being better for boys than for girls. The discussion by the respondents is not perceived as relevant (in Denmark). It is more relevant that SCs have strength in relation to getting weaker students to understand science. Industry lacks more science-interested girls. There may be differences in the time boys and girls use at an exhibition.
3. Schools can learn more about teaching science from science centers than the other way round.	SCs can offer specialized professional scientific knowledge, from which both students and teachers can learn. It's about mutual collaboration and dialogue. By creating awareness of the differences between schools and SCs, we can bring forth experiences about what each can contribute. Course activities by SC teachers can give schoolteachers a common language and create enthusiasm for science subjects. Schools make the most of visits to SCs, if there are ideas thought up beyond the actual visit. A before, during and after.
4. Science centers should not promote science careers - that's not their job.	To promote scientific career paths are not the SC core value, but it's a really nice side effect. SCs bombard with scientific events - and that's good. It is important that the SC does not promote a scientific career over another - Explainers*, who are engaged in a scientific career, can serve as role models. *People at the Experimentarium who are at the exhibition and can explain about science.

5. Science centers rarely focus on the relationship between science and industry.	SCs focus on this relationship, but it is not clear to the pupils. Focus on this relationship, for the pupils, is to be processed outside the SC SCs focus on science - and society A main focus on industry in exhibitions does not attract visitors. There are possibilities for greater focus on the trinity between industry, SCs and schools.
6. Students acquire skills in science centers, which are highly beneficial for their lives after school.	SCs do not directly have an extremely advantageous coupling for life after school. SCs influence, inspire and produce seeds. It depends on the further work with the students' perceptions and experiences.
7. Most science centers do not do enough in the way of promoting creativity, innovation and in contributing to a knowledge society.	Accessibility to the physical center is important for creativity and innovation. SCs do not promote creativity and innovation directly in physical centers. Creativity is everywhere - even in cyberspace. SCs must create ripples in the water after visits and outside the physical center. More available material, which lies outside visits to SCs, will bring more 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.	It does not matter how much you know about a subject, if you cannot communicate it. Exhibitions that require cooperation arouses interest - these can result in a scientific yield.
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.	Sparring in the group talk, listening and feedback - helps to give higher marks to both the weak and the skilled students. When hiring, the hard skills are assumed and the position goes to the one with the strongest soft skills. Hard and soft skills cannot be separated. Hard skills can determine if you are out of the group - therefore the group work motivates and drives the hard skills.
10. Visiting a science center has little impact on whether students follow careers in STEM.	The effect cannot be measured, but SC may be a pawn on the road. It's more important how the media presents SCs
11. Science centers do trigger the attention of children, but do not invest in learning processes with real long term impact.	It is not either or, however, the primary investment is to arouse curiosity and plant seeds. SCs do not invest in long-term objectives at the exhibition, but they do it, for example through learning materials. Training materials from the SCs are great - the teachers hold the responsibility for implementing the long-term goals. The teacher can gain enthusiasm and input, from e.g. courses from - and visits to SCs, this is contagious to the students. Curiosity aroused at the SC can be very long-term.

Figure 1: Summary of results

1. Introduction

This report is the Danish contribution to the ASTC study in Europe. The study intends to examine, whether science centers, which offer an environment that involves interdisciplinary, problem solving, group work, etc., are more effective in preparing children for the knowledge economy. "More effective" refers to previous studies that have shown that students who choose a scientific career often encountered science outside the school. Can SCs contribute to these experiences? The question is explored through two focus groups.

1.2 The author's notes

The description on how to produce output from the focus group study is limited. Therefore, the choice has been made, to design the report as we see fit. Furthermore, the scope of the report is not disclosed in the description. The scope of the report and the analysis are performed according to our own assessment and resources available. The intention is, that this report could be used by ASTC and within the Science Center Experimentarium.

2. Methods

ASTC has designed 11 statements, which are discussed in the respective focus groups. These are found in Section 4. Situational maps are used as inspiration for highlighting interesting topics and the recitals appearing in the respondent's discussions (Clarke, 2003). The theory, described by Clarke, is a constructivist supplement to grounded theory. It assumes that the data is analysed for codes and categories, treated and later forming theory, grounded in data (Clarke, 2003). This means that the data from the focus groups are categorized for redundant topics, to present the participants' utterances in a condensed form. However, the report is limited to present the condensed topics and does not seek to form any new theory.

Maria Zachariassen and Thea Hebsgaard, graduate students at Aalborg University CPH and trainees at Experimentarium facilitated the focus groups. Both have substantial experience in organizing focus groups and working with qualitative data.

3. Data

The data consist of two focus groups held with respectively five and six participants per group. The participants were:

Group 1:

2 representatives from science centers (1 woman, 1 man)

1 representative from the industry (1 woman)

2 primary school teachers (1 woman, 1 man)

Group 2:

2 representatives from science centers (two men)

2 representatives from the industry (1 man and 1 woman)

2 primary school teachers (2 women)

The discussion is recorded on audio and partially transcribed. The transcript provides the basis for the results presented in the following section. Text in italics (not in bold) are direct quotes. The characters "[]" indicate words added to the transcription in order to enhance the reading and understanding expe-rience.

4. Occurring Topics

The redundant and interesting topics that emerged from the focus groups are presented under each statement to create an overview for the reader. It will be noted when certain aspects are repeated in several statements.

4.1 Statement 1

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

Topics:

Learning is an important element at SCs, as well as in schools, but it is important that the way of learning in SCs is playing and free - not traditional blackboard teaching.

In the first focus group the interesting dichotomy emerged, that schools are a dry and boring place: *but that science centers have to be a place, where you really get to play* (representative of SC). However, it is highlighted: *they have to learn in a fun and new way* (representative from industry). Respondents pointed out, that both places should be learning places, but that free frames and the playful aspect of SCs, are important factors in the learning environment at SCs.

However, a teacher from focus group 2 opposes this dichotomy. She points out that she teaches (in primary school in science and technology) in a way, that is not just blackboard teaching. She adds: *it is such a tinker-*

mess-rave subject and my approach to [it] is very, very far from sitting still for anything. And such places as here [read: SCs] are very good at underpinning this [read: tinker-mess-rave education]. **It can be suggested, that SCs can help to foster a more unconventional teaching and that schools and SCs do not appear as opposites, but complement each other in this case.**

You can learn something at SCs without noticing it - the free environment can enhance learning. In continuation of the topic - learning through play, it is highlighted in the discussion: *yes you learn something without actually being aware that you are learning it (school teacher).*

The respondents in focus group 1 also define the SC as *a sanctuary*, where ***you can't: be held accountable for the results*** (representative of the industry). The respondents indicated that the students should learn in a fun and innovative way: *They can acquire some knowledge through play* (school teacher).

SCs are not amusement parks

In focus group 1, an interesting comparison between SCs and theme parks was mentioned. Amusement parks described as a place, which is just fun and games and where the attraction: *does not have a question mark after it* (representative from industry). Furthermore it is articulated, that even if you do not visit a SC in a school setting, *you learn something anyway* (ibid.).

SCs can create wonder and motivate learning in the school.

In focus group 2 it is argued, that the SC can help to arouse wonder and curiosity for the students. Furthermore SC can help to motivate by providing potential purposes of learning science: *Why should I learn? And I think you can get this from SCs* (representative from industry).

4.2 Statement 2

Science centers work better for boys than for girls.

Topics:

SCs are not perceived as being better for boys than for girls. The discussion by the respondents is not perceived as relevant (in Denmark).

An interesting view is that it might be an interesting discussion about how SCs are marketed: *I think (maybe) it depends on how it is marketed from the SC* (teacher). The example is given, that a great race car may attract boys more in relation to sell the content of the SC. But the respondents agree, that the SC works equally well for boys as for girls.

It is more relevant that the SC is strong in relation to getting weaker students to understand science

Focus Group 1 also agreed that a discussion about what SCs can do for weaker students in relation to the strong ones, are far more relevant, than the question about boys vs. girls.

The industry misses more science-interested girls

The industry representatives in group 2, argued that they miss more girls choosing a scientific career: *there is not enough diversity and something must be done about this problem* (representative from industry). In the further discussion it is pointed out, however, that the problem is on a social scale and it may be difficult for SCs to advance this further.

There may be differences in the time boys and girls use at an exhibition

A representative from a SC refers to a research conducted at Experimentarium, which shows: *there are big differences in how much time they spend on individual exhibitions. The design influences and it holds importance, which colours and buttons [there are]* (Representative from SC). However, the teachers from focus group 2 also express, that they do not think SCs work better for boys than for girls.

4.3 Statement 3

Schools can learn more about teaching science from science centers than the other way around.

Topics:

SCs can offer specialized professional scientific knowledge, which students and teachers can learn from.

Group 1 pointed out, that teachers have a broad training in relation to science and it can be rewarding to visit a SC because: *Here are the specialists* (teacher). A representative of SC complements later. *I have technical knowledge, but if I do not have sparring with some teachers about how it should be communicated, then I would not get it to work - education wise.*

It's about mutual collaboration and dialogue.

In group 1 the respondents oppose to the word "more" (in the statement) and point out, that it is not about; one can learn from the other organization, but that

schools and SCs need each other. ***A respondent points out, that SCs: [could not] make teaching activities if they do not have dialogue with teachers about what is going to work*** (Representative from industry). A teacher points out further: much of what SCs stand for, *we cannot do in school. That's what they are for*. This can indicate, that the SC has an advantage over both opportunities for subject-specific knowledge and facilities in relation to schools, which are attributes, which are difficult for schools to learn from, but also point to more of an economic issue.

By creating awareness of the differences between schools and SCs, we can bring forth experiences about what each can contribute.

There are differing views in focus group 2 about whether the school or the SC has "stalled" and hereby need to learn something new from the second instance. A representative from the SC points out the sentence above. Another SC representative explains: *yes to teach the school again*. Another SC representative points out that *awareness of the differences will make SCs. a very good alternative to the school.*

Course activities by SC teachers can give school teachers a common language and create en-thusiasm for science subjects.

A representative from the industry points out, that respectively Experimentarium and places in the United States produce educational materials. Another respondent points out, that the training of teachers contributes to the perception*: here's something you can teach your students and then they get more enthusiasm for science, and it's good* (representative of SC). The teachers elaborates that courses in the SC provides the teachers with a common language and frame of reference. In addition, we point out the potential, which these opinions may contain to give SCS the opportunity to be an intermediary between new knowledge and the population - because teachers' contact with SCS, apparently, *is to create a common [science] language* (teacher). The teachers might pass the language to the students, which are likely to be linked to enthusiasm and motivation (see the topic "SC can create curiosity and motivation for the learning in school").

Schools make the most of visits to SCS, if there is thought beyond the actual visit. A before, during and after.

The teachers in group 1 showed enthusiasm for SC (Experimentarium) courses for teachers. They express, that they especially learn more from SCs if their "regular" teaching also is included. This is explained in the quotation: *how can one make teaching [the teacher] that are adjacent to use it in teaching [for the students] and similar to visiting Experimentarium. The students said: what we learned at home really matters, but when we sat at Experimentarium everything was just more fun and prettier. Making courses possibly with the combination of how to use Experimentarium might also be a good topic to rise in relation to teachers (teacher).*

A representative from the SC adds, that SCs (at least in Denmark) have become adept to involving schools, and as the schools develop, then the SC also has to: *I would say that based on our skill in communicating science, we have also become adept to really go to the school and give them good ideas for teaching. Maybe we have gotten a little stuck and the school has moved, but then the science centers must move with it.*

4.4 Statement 4

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

Topics:

To promote scientific career paths are not the SC core value, but it's a really nice side effect.

In both focus groups it is agreed, *that it is not SC's primary task, but it is: really well as a side effect* (representative from SC) *and if it happens it's great* (representative from industry). The teachers note further, that: *there are many things, which influence the career, they choose and hereby it is very difficult to assess, whether the SC was the place, which made the difference.*

SC bombards with scientific events - and that's good.

A teacher explains: *I feel bombarded with materials from* SCs. try this and try this science festival - it's good to be bombarded. It may be noted, that the activities outside the SC's exhibition itself can help to get science on the agenda and give inspiration.

It is important that the SC does not promote a scientific career over another - Explainers who are engaged in a scientific career can serve as role models.

In focus group 2 it is emphasized that: *if you have to accept whatever [read: Statement 4] it must be to say that we should not promote a scientific career over another. I think we need to keep us from this* (representative of SC). The respondent explained further, that Experimentarium has good experiences with the pilots which students can experience in the workspace of science: *we experience that when our explainers are in the process of a scientific career and have started at the university, some of them are really (...) can dissect a fish, (...) and in this way I think they can be role models for any of*

the schools that come to Experimentarium. In this way, I think we should take advantage of the vibrant people which are in a science center and which are in the process of a scientific career (Representative from SC).

In this regard it is emphasized that a good and exciting resource for children in relation to science, may be the opportunity to talk face to face with the one that has chosen such a type of career.

4.5 Statement 5

Science centers rarely focus on the relationship between science and industry.

Topics:

SCs focus on the relationship, but it is not clear to the pupils.

Several of representatives from the focus groups point out that it is clear, that SCs focus on the relationship between science and industry: *surely they do then. Focus on inventions and exhibitions at Experimentarium is all about collecting these two things. It's really good to involve industry and get sponsor-ships and get them to take an interest in it.*

To which a representative from SC adds: *the question for me is probably more how much the students see (...) what they do or what students perceive. I think yes there are lots of collaboration and coopera-tion and focus on the industry. But I do not know how much the students actually get out of it. Do they really experience, when it is sponsored by the industry?* To which a teacher adds: *it is perhaps not so relevant [that the students watch it].*

Focus on the relationship, for the pupils, is to be processed outside the SC

To make students aware of the relationship, a representative from the industry in focus group 1, points out the possibility: *It can be something in the after work. It may be that the students have to describe how it is linked to the industry. I do not think they think of the clutch. It is very important that this is focused in after work. Teachers will have more focus on this, than the student. The intention is there from the SC, but it appears not directly clear to students. That is the teachers' job.*

To which a teacher responds *it's essential that teachers involve specific companies including such as Novo Nordic - they think society and take it to a more social scientific level. However, this will not encourage interest in science: but at the same time there's not many students who think; if I want to go out and solve the world's industry challenges, I have to be a scientist. In a sense it is not sufficiently disseminated that it is possible to solve much of the problems by studying science, rather than social sciences.* (Representative from SC)

SC focuses on science - and society

Despite the fact that several representatives describe that SC focuses on the relationship between industry and science, a representative from the industry points out a relationship between SC and the social sciences: *I really think they are taking on society. Societal problems, what shall we say challenges that Denmark, or lack of resources, or limited resources. This is themes they bring up.*

A main focus on industry in exhibitions does not attract visitors.

Compared with the emphasizing, that SCs focus on the relationship it is not attractive to visitors, if the relationship is brought in focus: *but it is challenging to make experiments that are sufficiently entertaining and instructive acting on industrial products (...) It is the place in our exhibition space where there are the fewest visitors* (representative from SC). To which a representative from industry provides an example of an exhibition funded by a Malaysian oil company, which only dealt with the oil: *and they (the organizers) are now fleeing away and making different types of activities in science centres - precisely because of too few visitors.*

There are possibilities of greater focus on the trinity between industry, SCs and schools.

To explore the point of "Focus on the relationship, for pupils, need to be processed outside SCs" a teach-er representative in focus group 2 describes: *well, from a school perspective, we suppose a culture here in Denmark, where we are up to work with the local community, and there is certainly a limit to how much sponsoring decidedly a municipality or a school can get. Then we go to Experimentarium or Danfoss Universe. So you do not support so we may well like to get this house on our school, where we could build robots. It is really hard to get sponsors in the companies In Denmark, even if you could document; what it is we want and we have experience from Norway - that it works and it increases the interest and so on.*

To which representative from SC describes: *but it is difficult to focus more on the trinity, between schools, industry and SCs. There's some industry to be seen out there (...). so I had despite the talk with Novo Nordic recently, who want to take classes in the organisation. They had such a hard time with that. Maybe we can do something to actually create a trinity. Maybe they can have their laboratories at SCs, so that Novo had a laboratory you or your school could visit.*

The representatives demand thus a clearer trinity between industry, SCs and schools, if you want more interest and motivation in relation to science in schools.

4.6 Statement 6

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

Topics:

SCs do not directly have an extremely advantageous coupling for life after school.

Several representatives from both focus groups do not describe SCs as making highly beneficial impacts on life after school, but that: *science centers make an influence to young people as they choose something like that after school (Representative from Industry) as well as: perhaps you should re-phrase it as they say students get inspiration from science centers, which are advantageous for their student life* (representative of SC). The respondents describe, that it can be difficult to tell whether the SC has an extremely beneficial effect on each student, but that most people are influenced by the experiences they have: *most have memories and they become inspired and this creates and awakens an interest in some people.*

SC influences, inspires and produces seeds.

A representative from SC describes instead: *the (SC) has planted a seed and they have a certain influence, we can surely say*. To which a teacher adds: *I do not think it's the skill. I think it's like more inspiration or something. Curiosity was aroused or you become aware of something.* A representative describes: *if you need to develop ability for something, you have to work with it for a long time and this [does] not happen in a science center*.

It is articulated, whether SCs ever would be able to create the experience of long-term science skills, if these are not processed after a visit.

It depends on the further work with the students' perceptions and experiences.

Refers to "Focus on the relationship, for the pupils, is to be processed outside the SC". The acquiring of skills depends on creating favourable scientific abilities, and: *whether it is processed afterwards* (Representative from SC). Another representative from SC describes: *if you just come [to the SC] and there are no teaching programs that you might put into a frame, so it is an individual knowledge. The individual might have gotten the point, but you will never find out. So if it is a group of pupils, they would be able to pick up on it by doing it after. It will, as it was described in the previous section, therefore be up to the teacher, whether the SC can be instrumental in creating long-term science skills after school. However it is individual because the experience, for example, from upbringing/experiences from childhood also has an influence.*

4.7 statement 7

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

Topics:

Accessibility to the physical center is important for Creativity and Innovation.

Focus Group 1's first assessment to statement 7 is described from its location (accessibility) to a SC: *So if we now take the location of this (Experimentarium). It is difficult to get to, it is not a contribution in my world, but it is more on the physical, the availability, you know. It's probably not, what the statement is about* (Teacher Representative). To which a representative from SC describes: you can say*; it is maybe tipping a little out in the wrong direction, when you put it up to be a place that is more of a tourist attraction for people who are in Nyhavn, rather than being an attraction for schools, which many schools should be able to get to - possibly by the funicular railway or by bus.*

According to several representatives the locality inhibits thereby the creativity and innovation at SCs. It is important: *what part of it is easily accessible, because if they (science centres) should be contributing to the knowledge society, then it is surely not just the few who come to visit, then I suppose everything else is also important* (Representative from SC).

SCs do not promote creativity and innovation directly in physical centers. Creativity is everywhere - even in cyberspace.

A representative from the industry describes: *creativity and innovation, it's not just one place, there are many other places, cyberspace and on all media platforms - but they are everywhere. To which a representative from SC adds: to promote creativity, an average exhibition makes it very rarely - be-cause it's too predictable what happens there. There are very few places where you can be for a longer time and do projects and experiments. So the best way of ensuring creativity, could be that you admired that there is a creativity behind the exhibition that is made.*

A teacher representative describes: *in the school system we know about SCs. I knew there was some-thing called Experimentarium and the planetarium but the visibility*

of them and having them and SCs making a contribution to a knowledge society, then they damn be more visible I think. (...) in the media and such.

SCs must create ripples in the water after visits and outside the physical center.

Several representatives describes that SCs do not do enough for pupils to be creative: ***it's rare you get to move things around and create something (...) so my problem with this creativity and innovation of science to me is that it should therefore not just be about inventions (...) it must be about doing something with the things you normally do in science teaching.*** *Well I have seen many school projects that are really creative by building small houses. It is a bit important that creativity is made to do something, which is about science. One can assume that she thinks SCs are not doing enough about it.* Another SC representative describes: *It quickly becomes a playground. The goal should be that it should be knowledge intermediary. They must create ripples in the water.*

A representative from the industry gives an example in the form of Lego League: *it is something that makes something like running a project over time and can also coming up with new ideas and ways of doing things.*

More available material, which lies outside visits to SCs, will bring more creativity and innovation.

Compared to contributing to the knowledge society outside the SC a representative from SC describes: *then you have to go and make more easily available material. Do something that is easier to spread out and use in the North of Jutland (a part of Denmark far from Experimentarium), to give an example – something that does not require a trip to Experimentarium to be able to use the material. To which a representative from industry adds: you could get on the map with an industrial company up there (in North Jutland) where they have made some fishing factory. Have a pavilion for a few months where all the schools can come up there and try.* Which also was described in the section on "There are possibilities of greater focus on the trinity between industry, SCs and schools."

4.8 Statement 8

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

Topics:

It does not matter how much you know about a subject, if you cannot communicate it.

The teachers in focus group 1 say that they teach the same amount of soft skills as hard skills: *I will say that where I work now, that we learn them as many soft skills that we teach them specialist knowledge, and it's very academic subjects in comparison to many other places. but you (...) cannot be a talent without finding out how to communicate on what it is you know (...) so we work as much with teaching them how to communicate and talk with others who are wise in other areas and not just geek out on their own little subjects (...)* (representative from industry)

They supplement there to, that you cannot work together on an academic project - unless you also master the soft values: *if they cannot figure out how to pull it down to a level and talk about it and work on some project - then it does not matter how much they know (teacher). As well as: but this is inevitably connected in my world and if you cannot get them to work together then they do not learn anything* (teacher)

Exhibitions that require cooperation arouses interest - these can result in a scientific yield.

Representatives from SC reports that they have good experiences with exhibitions, which requires co-operation: *and where the most famous line up we have is the building exhibit with the crane where the children need to work together to move it and it's really fun to watch* (representative from SC)

This result in, that in the future, more of this kind of exhibitions will be made: *we [Experimentarium] open a new exhibition, based on multiple users. Constructions you can not use alone. The idea being that it is the family that will use this exhibition in principle so you have to be at least two and preferably four or five people on each exhibit* (Representative from SC).

This concludes with the point: *that it's really the thought that the soft skills can create a scientific yield* (Representative from SC).

4.9 Statement 9

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

Topics:

Sparring in the group talk, listen and feedback - helps to give higher marks to both the weak and the skilled students.

In focus group 1 especially the industry representatives and teachers are emphasizing that they do not agree with

statement 9. *A teacher begins by explaining: sparring in the group and I'm sure it gave good input to both the weak and the skilled* (teacher). She states further that: *I'm sure it will be a better assignment when the students discuss things. That way I do not think it gives lower but higher grades.* (teacher) to which another teacher agrees.

A representative from the industry elaborates on the qualities of the soft values that give better results*: it happens of course also with us when we are able to discuss with others - what do you think? If it is soft values to talk and listen and give feedback - then we agree* (representative from industry).

When hiring the hard skills are assumed and the position goes to the one with the strongest soft skills.

A representative from the SC highlighted the above several times, including in the statement: *I will nevertheless say that you hire people on the assumption that of course they have the hard skills, and then you recruit those with the strongest soft skills.*

Hard and soft skills cannot be separated.

The teachers emphasized that the skills cannot be separated: *I like to call into question how one learns the hard skills without using some soft too. I do not think you can separate [them]* (Teacher).

Another teacher points out that this is also necessary to consider which students we want "on the other side", in relation to this statement: *yes it is definitely a correlation. You cannot separate the two skills. Also there is also a view of humanity behind it, I think so. How if you look at it holistically (...) what is this product, what's the deal we want out on the other side?* (Teacher).

Hard skills can determine if you are out of the group - therefore the group work motivates and drives the hard skills.

Representatives from all areas in the 2 groups emphasizes that the soft skills are motivating for the hard skills, respectively, in school and in business. In the following a short sample of this discussion is presented: *if you look at such a thing as group work, then there is nothing that is as motivating for the hard skills than to satisfy the group, because if you do not perform then you are simply out - hence group work is strongly driving the hard skills* (Representative from Industry)

I very much agree (Representative from SC)

Especially when you get further along in school (Teacher)

4.10 statement 10

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

Topics:

The effect cannot be measured, but SCs may be a part of the road.

Both focus groups provide initial examples of why this relationship cannot be measured. They point out, among other things, that it also depends on factors such as heredity and environment, and whether you have an inspiring teacher. Another example is that: *it may, as well, be the generous walk down to the river, where there is fishing, which can be the turning point that makes you become a biologist* (Teacher).

Both groups, however, agree on the possibility that the SC may have some sort of effect: *it does not have a sale-rewarding effect. It's just a side effect of a degree* (Representative from SC)

It's more important how the media presents SCs

A teacher points out the success of the television programs: Store Nørd and Lille Nørd (Science shows for kids - in English: Big Geek and Little Geek) and how these might generate interest in visiting a SC: *they deal with science themes and it runs very well and it's not something about SCs but it creates the interest to get into the centers. They're so good* (teacher). Another teacher continues: *[SCs] are just as Store Nørd and Lille Nørd and everything else that create an interest. The more ways to develop this interest, the better you learn it.*

4.11 Statement 11

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

Topics:

It is not either or, however, the primary investment is to arouse curiosity and plant seeds.

In focus group 1, a teacher questions the statement: *is it primarily to arouse curiosity and attention or interest or is it primarily the long-term* (teacher)? To which the answer was: *it's number one* (representative from industry). A teacher explains, that it is important: *to arouse curiosity. Providing a seed, and another teacher describes the difficulty of long-term goals: the long-term is a combination of everything else and it becomes difficult for them to make the long-term [goals].*

SCs do not invest in long-term objectives at the exhibition, but they do it, for example through learning materials.

A teacher elaborates on how the training materials give teachers the opportunity to implement long-term goals of the visit: *the learning process itself, that it is to make educational material that can be taken into the school at home but it is the teachers who make the long-term impact, I think. The other teacher agrees that SCs: can help to produce or present material.*

In focus group 2 the subject was elaborated: *the science centers should invest in some processes (...) more far-reaching than it is to go in and experience a science center and go out again. It's about going out and creating it there before, during and after. that you make something out of preparing an experience, a simplification, a breeze and then a post-processing (...) it is the way to draw the process out and make real long-term effect* (representative from SC).

Training materials from the SCs are great - the teachers hold the responsibility for implementing the long-term goals.

The teachers point out that they work with long-term goals in the school, and how the teaching materials from Experimentarium: *is always aware of common goals (sat by the state to the elementary schools) and there are always these skills and it is the long term goals we work with as they have (...) I think that after all it is great.* The teacher points out, that SCs invest in long-term goals, through the teaching materials they send out. In addition, she describes: *it is also often part of a course or visit, but it should ideally be considered within a context of the goals, we are working with.*

The teacher can gain enthusiasm and input, from e.g. courses from - and visits to SCs, this is contagious to the students.

A teacher describes that old materials from Experimentarium are still used: *the teachers who have continued to use some of the things which still are to be found around, then it's the teacher that makes it [work] (...) if it has longer lasting effects depends largely on how teaching takes place.* Another teacher adds that*: it can therefore help to arouse enthusiasm when you come in here [at SC] and get something you think is cool and you get an input too because of the enthusiasm -both on a course and in the exhibition - because the enthusiasm you experience during the day is contagious.*

Curiosity aroused at the SC can be very long-term.

It is further pointed out that the visit may have long-term effects via the curiosity aroused by specific exhibitions: one might also say that the long-term effect is of course that you have felt the curiosity where things are happening as it happens. And it spreads typically within science, and interest in the area. Why is it just that it goes up when the crane moves up? If you get it in your head, the curiosity of why does it as it does it is very long-term (representative from industry).

6 Israel

Catalyzing
STEM Innovations Skills in Informal Learning Input from Israel April 8 2015

Israel Focus Group. Meeting February 8, 2015 14:00-15:30

National Policy on STEM Education and the Role of SCs in informal learning

The Ministry of Education wrote (June 5, 2014 Science and Technology Administration, Shoshi Cohen) Science and Technology Learning Guidelines for Elementary (grades 1-6) Schools (Note guideline 2, museums include Science Centres) as follows:

"Details of guidelines for science and technology learning in primary schools:

1. Experiential learning the way to scientific inquiry, problem solving and technological process:

   Key experience science and technology classes

   Explicit teaching of scientific inquiry skills

   Experience a whole process of scientific inquiry, problem solving and technological process

2. Out of classroom learning (museum, safari, nature reserves, zoos, observatory, etc.)

   Establishing out of classroom learning skills, broadening and enrichment of scientific and technological knowledge, assimilate scientific inquiry, motivation, fostering values education and education for sustainability

3. Integrating ICT tools in the teaching, learning and assessment to improve learning functions

adapted to the 21st century

Collaborative learning using simulations and collaboration tools online environments to promote learning and consolidate knowledge and skills

4. Improvement of teaching, learning and assessment for raising achievement

   Guiding assessment culture of teaching and learning processes

   Using a variety of assessment tools Learning coefficient feedback

5. Expansion of the teaching-learning time, individual time."

Outcomes of the focus groups

List of participants (function/gender)

- Convener – Dr. Ronen Mir, Physicist, Formal and Informal Science Education
- Dr. Yossi Elran, Informal Science Education, M
- Dr. Erez Garty, Biologist and Informal Science Education, M
- Dr. Orli Lachish, Formal (Chemistry teacher) and Informal Science Education, F
- Dr. Ronen Mir, Physicist, Formal (School Principal) and Informal Science Education, M
- Hana Levin, Formal Science Education - Physics Teacher, F
- Benny Klingman, Formal Science Education, Physics Teacher, M
- Dr. Revital Duvdevani, Industry and Informal Science Education, F
- Dr. Yaacov Lavie, Industry and Informal Science Education, M

Methodology (to see whether protocol was followed)

The participants sat around a table and the discussion was videotaped. The project was introduced by the convener. Each statement was read and each participant gave their view going around the table, starting at a different person each time. For each statement, after the first go-around, individuals could add a comment as they wished. At the end of the 11 statements general comments were given (Question 12).

Session was Videotaped by Itzik, photography unit, Weizmann Institute of Science; Transcribed by Rachel Silberberg, Evaluator, Weizmann Institute of Science; Translated into English by Ronen Mir, Weizmann Institute of Science

Discussion on the statements Was done during the focus groups.

Conclusions N/A

Conclusions per statement (summary) Summarized below.

Conclusions on the Role of Science centres in the acquisition of soft skills N/A

Advantages of informal learning in science centres and museums N/A

Challenges for informal STEM education through science centres N/A

Recommendations N/A

Statements

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

Everyone agrees with this statement. Enjoyment in Science Centers must be maintained. Enjoyment brings motivation to the students, in this case motivation for studying science. This encourages schools to teach science in many ways, and to create a more intense relationship with Science Centers. One such partnership highlighted are Science Clubs, where structured .and enjoyable learning takes place

Science centers work better for boys than for girls.

Everyone agrees that science centers should be a-gender. We see no difference for young children visitors, girls and boys both enjoy and operate the exhibits equally. For teenagers Science Centers have more items and topics of interest to boys than girls. Girls tend to aesthetics (how things look) and boys mechanics (how things work). Guides and explainers have a significant role-model part in closing the gender gap. Social education needs to change to prevent the differentiation created at the teenage years.

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

Six do not agree with that statement. There is mutual learning between the schools and the centers. Each has its own strengths.

Two participants agree (Yossi and Erez) with the statement that science centers do not learn from schools. The amount of students and interaction hours are much larger at schools. Their goals are different - Schools aim for long-term learning, via extended interaction between teachers and students that affects learning.

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

All objected to this statement. The central role of Science Centers is to encourage curiosity, interest and exploration in science, encourage success, all this by role modeling. This results in promoting and encouraging scientific careers. A suggestion is made that encouraging scientific careers should be part of the SC agenda.

Science centers rarely focus on the rela-.tionship between science and industry

Eight did not agree with the statement. There is now more emphasis on industry In Science Centers, especially on high-tech, and less on traditional industries. The collaboration between Industry and Science Centers results from Industry funding some knowledge centers or their programs, in order to encourage students to reach those areas. Industries are perceived as implementing solutions to problems and challenges of everyday life and this attracts students and .in particular girls

One (Benny) agrees with the statement, claiming that the schools and science centers do not focus on industry.

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

Opinion is divided half agree (Ronen, Revital, Kobi, Yossi), pointing to long-term activities, where skills such as cooperation and teamwork are acquired. Longitudinal activities can affect perceptions and change them. Half disagree (Benny, Hana, Erez, Orly) with the statement, pointing to short-term activities, like a one-time short visit, where it is not possible to acquire skills.

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

Everyone opposes the statement. Science centers contribute and encourage creativity. SC contribute to the knowledge and information society, where knowledge is a cultural value. . A suggestion is made that developing and contributing to the knowledge society should be part of the SC agenda.

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

All agree with the statement. It is important to teach soft skills and they can be learned in many places. It is beneficial to use Science Centers to develop soft skills, as the centers enable students, especially nerds, to receive .the opportunity to stand out and thrive

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.

Everyone opposes this statement. The opposite is

true - focusing on soft skills in schools will only help learning. The essence of education, beyond gaining knowledge, is acquiring soft skills and behavior. Schools need to develop additional soft skills and Science Centers can significantly help in this mission.

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

Everyone opposes this statement. Long interactions and even short visits to Science Centers have the potential to impact the students, and eventually crystallize to selecting STEM careers. An example is a student who attended a lecture by Nobler Laureate Prof. Ada Yonat, and then sent her a letter where she stated that she will study Science instead of advocacy.

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

Everyone opposes this statement. Short-term activities in SC generate initial interest and the understanding of a subject or two. Long term activities in SC have a clear investment for significant learning processes.

Bonus Question and Comments: Catalyzing STEM Innovations Skills in Informal Learning

All agree with this statement. Exposure to STEM in Science Centers is a catalyst for the acquisition of skills. Without such a catalyst there will not be a formal learning. Formal learning is needed to achieve the outcomes desired. Formal and Informal Science Education feed each other. The partition between formal and informal is problematic and grating. Science Centers strengthen the skills of innovation and the like.

7 Italy

Milan

National Museum of Science and Technology Leonardo da Vinci

September 4, 2014

Facilitator

Camilla Rossi-Linnemann

Participants

- 2 senior museum educators (referred to as: ST, VA)
- 3 high school teachers (referred to as: AD, AL, MO)

Please note that the 2 invited company representatives did not attend the focus group.

Overview and notes

The Focus Group would have benefited from the presence of company representatives, but the discussion was quite lively and participants expressed their opinions freely, referring to personal understandings and ideas stemming from their own experiences and work at the Museum and in schools.

The participating teachers were familiar with the Museum and had previously participated in projects for students and attended teacher training courses.

The focus group was conducted in Italian. It lasted two hours during which seven statements were discussed in depth.

The following report summarizes the reactions of participants to the proposed statements. Opinions that matched or overlapped were rephrased and grouped together for simplicity. Opinions that were personal have a reference to the individual participant.

Opinions that were not strictly relevant to the proposed statements were also briefly transcribed, unless out of context.

Introduction

The focus group was introduced by the Facilitator, who clarified the concept of "science center" and the idea of "soft skill". Throughout the discussion participants subtly expressed the need to better define the term "soft skill". This perhaps indicates that one of the first necessary actions would be to inform education staff in museums and schools to help them identify and acknowledge these abilities, both within themselves and in others.

Soft skills are important, but they can also be developed through other extracurricular activities such as sports, art, etc.

Sports are a good situation in which to develop soft skills. Especially team sports, that help develop team works and reactions to difficult situations while keeping in mind a specific objective.

AL – The more we expose children and teenagers to different types of stimuli, the more complete there education and training will be.

AD – The problems posed in sports are very specific, while within museums challenges are more complex and extensive.

VA – While in sports the competences that you develop are valued by your peers and by your trainer in relation to a specific objective, in Museums they are recognized as precious in themselves. At the Museum you can develop competences that are less "closed" and applicable to other fields.

AL – One of the nice experiences was coming to the Museum and having the students meet women science researchers (Editor's note: the teacher refers to the EU funded project "Science is a girl thing"). Seeing new role models is crucial for the students, it opens up new perspectives, new worlds that they wouldn't otherwise know about.

ST – I don't think there is a big difference between sports and museum experiences. In both occasions there is teamwork etc.

VA – The difference with sports is that, where there is a collaboration between school and museum, the students will be more aware of the development of their personal skills. In other fields, skills are developed by coaches and tutors for specific objectives. At the Museum we try to develop them so that they consciously become part of each student's personality.

At the Museum students are protagonists, following their individual learning path. The key is the collaboration between school and museum to make the students aware of their own skills and of the possibility to spend them in different contexts.

The job skills required today are very different from those of the past.

In the past the difference was made by what you had studied, with which professor, in which school. There were fewer trained people.

Now employers look more at soft skills. These make the difference between people, as there are many more graduates and many more different training options.

AD – Research works if people work together.

VA – If I were an employer I would like to know more about the individual character of a person. But how do you do that? Can you get to know a person's soft skills from a CV?

It is consequently also important for students to know how to recognize their own skills and to know how to communicate them, not only through their CVs.

AL – Now jobs are more "global", so you need more soft skills. Competences are probably the same as in the past, but soft skills are more valued.

ST – Jobs seem to be more interdisciplinary today, so you need more skills associated with relations and communications.

If we focus on the development of soft-skills, the test results in schools will be worse.

At first teachers all agree with this, stating that in schools there is little time and many students. It is thus not possible to think about soft skills. The national standards impose crazy pace and we need to transmit many contents to students.

How can we help students develop this? Perhaps by taking them here to the Museum to be "inspired". It is a brief experience but it touches some personal, emotional strings.

VA – This statement puts on the same level something that can be tested with something (soft skills) that can not be evaluated. Or can they?

AD – Perhaps if schools opened in the afternoon or had time for extra activities we could do it.

AL – Soft skills tend to emerge more in those classrooms where the teacher develops an empathy with his/her students.

VA – Thinking again, maybe focusing on soft skills could lead to better test results.

Participating teachers then ask themselves: "When would we work on this? At which stage of school? In which year?"

ST – It is crucial to build a continuity, working on soft skills constantly and perhaps developing evaluation methods that could be integrated in internal and national school tests.

Participating teachers then begin thinking that the best thing would be to integrate the teaching and evaluation of these skills throughout their programs, during all course years.

They state that they wouldn't know how to do it, but then make some suggestions:

AD – Teaching science with a methodology that is closer to the "open method" adopted by the Museum.

ST – Offering students the possibility to present their studies and work as they wish is already a way of helping them develop their personal ways to deal with things, understand them and communicate them. For example, you can see different personalities emerging when you listen to scientists' talks at FameLab or TED.

AL – Working with other sensitive teacher colleagues helps. Developing interdisciplinary connections. Working with the Italian literature teacher who often spends more time with students and has the advantage of working with "themes" that are often revealing of students' personalities.

VA – Yes, working across disciplines helps. Often we work with colleagues only if there is a problem to solve. For example if a student has problems, but we should do this in other occasions as well.

Science centers should create more opportunities for interaction between science education and industry.

The occasions on which the Museum has put schools in contact with companies have been very special and appreciated by students and teachers.

Specific moments that were valued here at the Milan museum included: activities where students met researchers at the Museum; having teachers discover the possibility of visiting firms or labs with their classes; putting teachers in contact with experts that would then give talks in schools.

Science centers stimulate the curiosity of children, but do not suggest learning processes with a long-term impact.

VA – We always try to have a long term impact but in order to do this we need: the collaboration of schools; the possibility to work on themes that are relevant to students; the resources to develop *ad hoc* projects with individual teachers and classes in order to respond to the teacher's specific education program; the resources to put schools into contact with the world of companies and research.

ST – The Museum tries to have a long term impact through teacher training.

AD – The action of museums and teachers would have a longer term impact if they could work with the same students continuously through the years. Often teachers are moved from school to school or from class to class, and even the longest Museum projects last for one year maximum. It would also be nice to be able to take the same school class to the Museum every year so as to follow up on their previous experiences.

AL – Impact on students is much stronger if one works with a colleague of a different discipline having attended the same refresher courses. In my experience when I, as a math teacher, worked with a physics teacher that attended the same robotics course at the Museum we could then split work, coordinate and thus make the best of the time we had to the benefit of students' group and individual work. Team work among teachers is crucial.

ICT can help schools and science centers in the development of skills needed in the working world.

AL – Some media, such as cell phones and tablets, can be distractive and isolate students. Yet if they are used correctly they can boost competences.

VA – There should be a training on how to use ICT critically, discerning sources of information and so on.

MO – They can help group work, for example through the sharing of documents, calendars, archives, planning tools, etc.

In science centers students acquire skills that can be of great benefit for their life after school.

ST – Even if the experience of a Museum for a student is usually brief, I believe in the "butterfly effect", where even a small change might lead to great changes in lives and personalities.

MO – I think meeting with researchers and professionals really helps students catch a glimpse of the future world.

AD – One of my students came for an event at the Museum and was really proud of meeting and speaking to a university professor, who inspired him in choosing which school to go to and boosted his confidence in picking a science career.

8 KOREA

GROUP 1

Statement 1. & Statement 11.

- At school, science education leans heavily toward theory due to safety and liability concerns as well as the need to comply with the curricular requirements. The science facilities are very good but are not fully utilized.
- Korea's extracurricular science education (hereinafter, the everyday science class) takes a hands-on approach to science education, viewing it as something to be enjoyed, not as an extension of school education.
- The class offers programs in which children can use the materials they come across in real life to explore the world of science in their own way.
- Through these activities, children learn to enjoy science, build their curiosity, explore the subject of interest, and develop a passion for science.

Statement 2.

- While the science museum program initially targeted boys, it now helps more girls to have better access to science, and take a more active part in the learning experiences.
- In the modern world, where communication between science and society is crucial, the role of girls, who are generally more attentive to detail, has become increasingly significant, particularly in science and related fields. In fact, most group presentations in the science museum program are given by girls.
- In the early phase of the project in 2004, the boy to girl ratio was 7 to 3. A decade later, the ratio is now 5 to 5.
- One of the main reasons for this growth is that the everyday science class and its excellent programs (e.g., parent night, local festivals, etc.) have helped improve the awareness of the parents, who have an influence on the education of their children. The class has also helped girls to have more access to science.

Statement 3.

- Because schools need to comply with the national ~~municipal~~ ~~internal~~ curriculum requirements, they do not enjoy much flexibility. Classes and lectures are focused on examinations and the acquisition of knowledge, because students will soon need to sit the national university entrance examination.
- The everyday science class is flexible enough to incorporate the latest issues in science, and encourage children to participate in and learn through experiments, research and studies. Schoolteachers have revealed that they also want to participate in the everyday science class, teacher training, and program seminars.
- Children remember and are satisfied with the projects that they get to carry out on their own, such as taking photos of stars at dawn.
- At a local high school, the everyday science class was held during regular school hours for the special-needs class for a semester. The students became remarkably confident, and the school and parents were very happy to see the change.
- While the recent revisions to the science curriculum have added many of the science experiments that have been conducted in the everyday science class over the past decade, according to the teachers who request the eve-ryday science class for training or content, most of these experiments are not actually being carried out at schools due to safety issues, the focus on the university entrance examination and in some case, negligence on the part of the school or teachers.

Statement 4. & Statement 10.

- As an everyday science class instructor for the last 10 years, I can see that the everyday science class helps children develop a scientific mindset (for example, by adopting a reasonable decision-making process).
- In the everyday science class, children learn to communicate with scientists naturally, can find out how sci-en-tists think and can make their observations.
- Children develop curiosity by observing, and test their own hypotheses in experiments. Children who have had hands-on experience working with an electric circuit will respond to problems like a light going out or a fuse

blowing in a calm manner.

- Unlike the classes given by science museums, the everyday science class doesn't offer programs or exhibitions that are one-off in nature. The class is more focused on science education provided by scientists (professors, re-searchers, etc.) who lecture at university.
- There are those children who naturally develop an interest in science as a career after meeting the scientists (many wish to study at science high schools and schools for the gifted, and become science teachers).
- In the everyday science class, children initially learn to develop their skills and to respond to problems. In the long term, this will help them gain a scientific reasoning and perhaps choose a career in science.

Statement 5.

- Experts can build a 4D frame with a single straw, but to an ordinary person, it may seem to be nothing more than rubbish.
- At school, science is taught by educators. At the science museum program, there are curators. In the everyday science class, science is taught by scientists (experts). This is one of a kind in the world.
- That is why the everyday science class is one of the best tools for bringing theoretical and practical science education together.
- The class is not a one-off class, nor does it force knowledge upon children. The projects it offers are at least 3 months long, and some last up to 9 years. All of them allow opportunities for children to observe, experience and explore.
- One regrettable thing is that the well-structured content of the everyday science class is not protected by intel-lectual property rights. This means that many schools and businesses simply take the content and use it without permission.

Statement 6. & Statement 7.

- A school is a place where diverse groups of children gather and are required to attend. There are hierarchies, and cliques are formed. In the classroom, questions are asked and answers are given by a few who have good grades.
- But with the everyday science class, children make the choice to attend. Here, they take part in individual or group experiments, voluntarily and freely ask questions or give answers, and experience success in the group's experiments or their own.
- For example, children may come to an incorrect conclusion theoretically, and then find out why and how they reached that conclusion through experiments. It is through this process that children grow and can enjoy suc-cess.
- Because the class requires that certain rules be observed, children learn to build good character.
- In particular, less fortunate children build self-esteem, as they achieve success in experiments, work as a team, learn to be considerate of others in group activities, and communicate with and form a friendly relationship with their teachers after class.

Statement 8. & Statement 9.

- Soft skills are about being able to communicate and express ideas. Some examples include good teamwork and communication.
- In sports and art, soft skills – the ability to communicate and express ideas – are also important, but these areas are usually characterized by the leadership of one talented person with a natural gift. The rest follows that leader.
- On the other hand, science experiments are a process in which participants express their ideas and work to-geth-er to find an answer.
- In group studies, each child has a role, and by playing their role, they learn to collaborate and to communicate, to express their thoughts scientifically, and to find the way to open new possibilities.

GROUP 2

Statement 1.

- Various experiments are featured in textbooks, but are rarely carried out at school. Instead, students are shown videos of those experiments.
- Students used to perform one experiment a semester for evaluation, but nowadays, they usually write a paper on a subject of their choosing during vacation.
- In the Everyday Science class, students love being involved in experiments.
- Those students who have been to the Everyday Science class find it helpful to their school projects, while other students who haven't had this experience frequently have difficulties with their projects.

Statement 2.

- This is a sexist generalization. While there may be certain areas or subjects that students of different genders prefer, the difference comes from their personal disposition, not their gender.
- It is true that there are more boys than girls in the Everyday Science class, but with primary school students, the ratio is more affected by their parents than by their own decisions.
- In engineering, it seems that the education is more effective with boys. Boys and girls differ in how they un-derstand the concept of spatial perception or tool handling, but it is usually girls that are more careful and atten-tive to details in science experiments.

Statement 3

- Schools also are changing these days. It can be observed that primary schools are increasingly placing an em-phasis on experiments and observation.
- Textbooks are well-structured based on in-depth exploration and experiments, but the problem is that teachers do not carry out experiments in class. The experiments found in the textbooks are rarely performed in class.
- Because the Everyday Science class takes and studies a subject for some weeks from the perspective of sci-en-tists, it differs from the science class taught by teachers from the educator's point of view.
- It is crucial that the Everyday Science class be fun and easy, and that it should not focus on teaching.

Statement 4. & Statement 10.

- (This argument seems to have been made because overseas science museums offer one-time education sessions or experiments.)
- Extracurricular science education offers an opportunity for students to find out for themselves if a STEM career is suitable for them or not.
- Extracurricular science education helps broaden the range of career choices, but it is schools that are respon-si-ble for in-depth education.
- The Everyday Science class provides an opportunity for students to find out what they like and what they are good at. It can suggest career options in science and in engineering. After all, the choice is up to the students, and there is no harm in introducing them to the options.
- In-depth vocational education should be carried out at school, but the Everyday Science class can also feature activities that recommend or help students explore relevant career options.

Statement 5.

- Isn't it the opposite in Korea? There are many cases in which scientific theories can be studied by looking at the real-life examples. That is why it is called the "Everyday Science class".

Statement 6.

- They learn a wide range of skills they need for real life. For example, many children who have never been to the everyday science class don't know how to use scissors or double-sided tape. Even older children in primary

school are not very good with scissors. School textbooks show how to change batteries or connect plugs, but most children have never done any of those things. However, the Everyday Science class helps children to actually learn and apply these useful everyday skills.

- Children are kept away from knives or scissors at school and even at home due to safety concerns. But children should be able to learn through trial and error, and the resulting injuries are usually not serious or life-threatening. It is worth asking ourselves whether we are depriving children of a chance to feel and experience because we are overly concerned with safety. In that regard, it is good that the everyday science class offers a wide variety of choices and experiences.

Statement 7.

- That is not true. A number of the activities in the Creative Science Class show that children are more talented and skilled than adults believe.

Statement 8.

- In assorted activities, there are some children who didn't seem very eager at first to take part sincerely. The everyday science class features many assorted activities and would be very helpful in developing soft skills.
- In the UCC projects, children actively and voluntarily looked for what they could do to contribute, and enjoyed the experience immensely.

Statement 9.

- School education is directly related to grades, and elements such as teamwork may not be too helpful in im-proving school grades. In fact, some children hesitate to lend their notes to others before tests.
- This could be complemented by the everyday science class, which is not related to school grades. This is all the more the reason why the everyday science class should be promoted and enjoyed by more children.

Statement 11.

- The everyday science class is led by instructors who majored in science and engineering at university. It allows them to help children to experience the science that scientists study and deal with, not the science that is taught for the sake of teaching.
- The everyday science class is not intended to induce children to choose careers in science, nor is it designed to foster future scientists. That is the job of the university.
- At the Science Sharing classes, we meet people from local children's centers who come to the class to help, and they seem to enjoy and wait for the everyday science class eagerly. They show great interest, with many saying that they didn't have anything like this when they were young.
- The everyday science class helps children become more interested in science, and realize that science is not a boring, difficult subject.
- It would be ideal if middle and high school students could also benefit from the practice-oriented everyday science class in addition to their science class at school, which focuses mainly on theories, but this can't be much more than a mere thought in light of the harsh reality that they still will have to study for the university entrance examination.

VA – The added value of the Museum methodology and environment is that it makes students feel protagonists, really in charge of their own work and learning experience.

AL – Museums are places where you can get in touch with “the real thing” and the “real world”.

One last comment with which all participants agreed was that it would be useful to better understand what soft skills are in order to help students:

- identify them;

- develop them;

- communicate them.

9. Portugal

Association of Science and Technology Centres

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

National Report, Portugal

Author: Carlos Catalão Alves

May 2015

Introduction

List of national contributors:

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

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 are 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.

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 prac-

titioners. 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

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-re-

lated 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 influenc-

ing 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.

Conclusions

3.1 Conclusions per statement

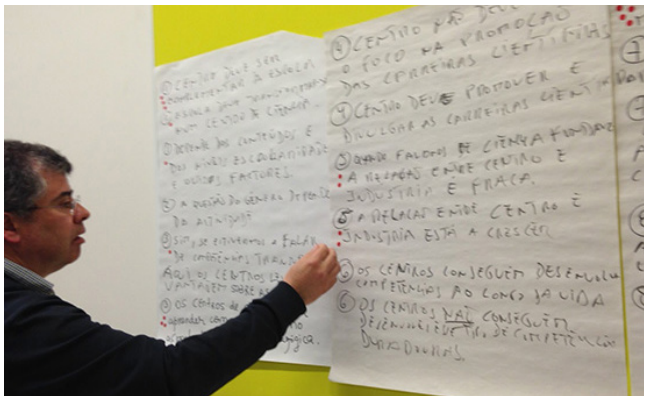
As already mentioned, for each of the 11 statements, participants drew collectively a number of key conclusions. With the guidance of the participants, the moderator wrote these conclusions, statement by statement, in several flip-chart sheets, which were then displayed across the walls.

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):



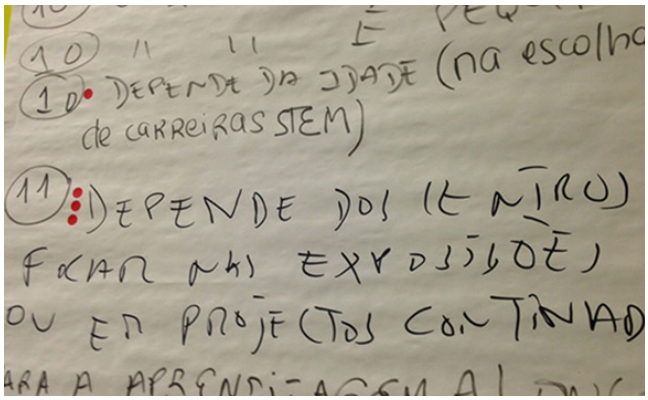


Table 5

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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About the Author

Dr. Carlos Catalao Alves

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.

10. Thailand

Focus Group Brainstorm Summary on:

The Role of Science Museums and Centers in Preparing Youth for a Knowledge-Based Economy

24th September 2014

National Science Museum Thailand (NSM)

Abstract

In order to improve museum operations in the task of preparing Thai youth for a knowledge-based economy, this survey was conducted a to collect data from participates who are involved in various sectors including; museum staff, science lecturers and those working in private sectors, all of which involve scientific issues.

Results from the survey show most participants agree;

· That museums and learning centers should be independent learning resources for the youth. However, the guidelines should be organized in order to be consistent to cover course content in different ways.

· The scientific content should be consistent between school and museum, but the styles and teaching approaches should differ.

· Techniques and materials should be different from those in schools. The museum's knowledge should be adapted into school lessons.

· Although the museums do not have a responsibility to lead children to follow a scientific career path; it should play a significant role to encourage and create inspiration.

· A task of the museum is to encourage children to realize the relationship between science and industrial sectors through exhibitions or related activities. This will motivate young people to be eager and try to find out answers.

· In addition, soft skills can be generated by museum but it might take time to encourage these skills and concepts, as a sole agent the museum cannot reach the goal of soft skill creation; other activities should be involved such as sports, art and music.

· Schools cannot focus only soft skills due to limited schemes and examinations that require time and effort. However, museums have an obvious influence to inspire the youth through science.

Background

The current world economy has changed from a natural resources-based economy to a knowledge-based economy, which motivates and creates economic and social growth effectively. Having members of the public talented in science, technology and innovation is a significant and vital part of establishing a knowledge-based economy. This economy, as it grows generates a need for a resource that has the ability to; be creative, progress cognitive science and push for technology and innovation. This requires continuous development for members of the public from early childhood onwards and the resource should be an ambassador in promoting general education and learning outside the classroom.

The science museum and informal learning have important roles to induce and develop learning in children and harness an experience that will lead learners to developing an interest in science.

Why is the collaboration with ASTC important to NSM?

Collaboration with ASTC has guided NSM though the process of this research to help achieve goals more effectively. NSM has an important role to foster and develop students of all ages to have scientific skills such as; mind sets of analytical thinking and problem solving so they can be applied to everyday life. Soft skills such as; team work and understanding others are also an important for students to develop. In order to achieve these goals for the benefit of the nation NSM asks; what should we do? This research, guided by ASTC was undertaken to understand the beliefs and views of stake holders, science educators, science communicators, human resources staff, people working in the private sector, researchers, teachers and lecturers. It also aims to let the stake holders share and discuss ideas.

Our goals

1. The result of the research; develop the role of the science museum in preparing children to be part of a knowledge based society.
2. To get a result that can be applied to the developments of the museum and its operations.

Objective

Sharing information and ideas between all stakeholders (mentioned above) and have a record of ideas and beliefs discussed.

Date of meeting

This seminar was held on September 23rd, 2014. There were two sessions; the morning session (10.00-11.40 hr.) and afternoon session (13.30-15.00 hr.)

Moderator

Mr. Thanakorn Parachai

Specialist in Science Communication

Program

1st round: 09:00 – 12:00 hr.

09:00 – 09:15 hr. Register

09:15 – 09:30 hr. Opening & Introduction

09:30 – 11:30 hr.

- Briefing

By Mrs. Ganigar Chen,

Director of Office of the Public Awareness of Science,

Nation Science Museum, Thailand

- Sharing & Brainstorm

Moderator: Mr. Thanakorn Parachai

11:30 – 12:00 hr. Conclusion

2nd round: 13:00 – 16:00 hr.

13:00 – 13:15 hr. Register

13:15 – 13:30 hr. Opening & Introduction

13:30 – 15:30 hr.

- Briefing

By Mrs. Ganigar Chen,

Director of Office of the Public Awareness of Science,

National Science Museum, Thailand

- Sharing & Brainstorming

Moderator: Mr. Thanakorn Parachai

15:30 – 16:00 hr. Conclusion

Detail:

ž **Aim:** to collect data on the given subject from stakeholders and these are; science educators, science communicators, HR staff, member of the private sector, researchers, teachers and lecturers

ž **Questions asked in session:**

1. We should let children just enjoy science centers, not turn centers into schools.
2. Science centers work better for boys than for girls.
3. Schools can learn more about teaching science from science centers than the other way round.
4. Science centers should not promote science careers - that's not their job.
5. Science centers rarely focus on the relationship between science and industry.
6. Students acquire skills in science centers which are highly beneficial for their lives after school.
7. Most science centers don't do enough in the way of promoting creativity, innovation and in contributing to a knowledge society.
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.
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.

10. Visiting a science center has little impact on whether students follow careers in STEM.

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

ž **Number of attendees: 8-10**

ž **Time taken for sharing: 90 - 120 minutes**

Participants in the Morning Session

1. Ms. Peeranut Kamhadilok National Science Museum Thailand (NSM)

2. Ms. Patthama Nukhong National Science Museum Thailand (NSM)

3. Mrs. Tatiya Jaiboon Science Center for Education

4. Ms. Bangon Boumeang Satit Prasarnmit Demonstration School

5. Mr. Nakarin Bharamorathat Thai Health Promotion Foundation

6. Ms. Sopit Khankhang Thai Health Promotion Foundation

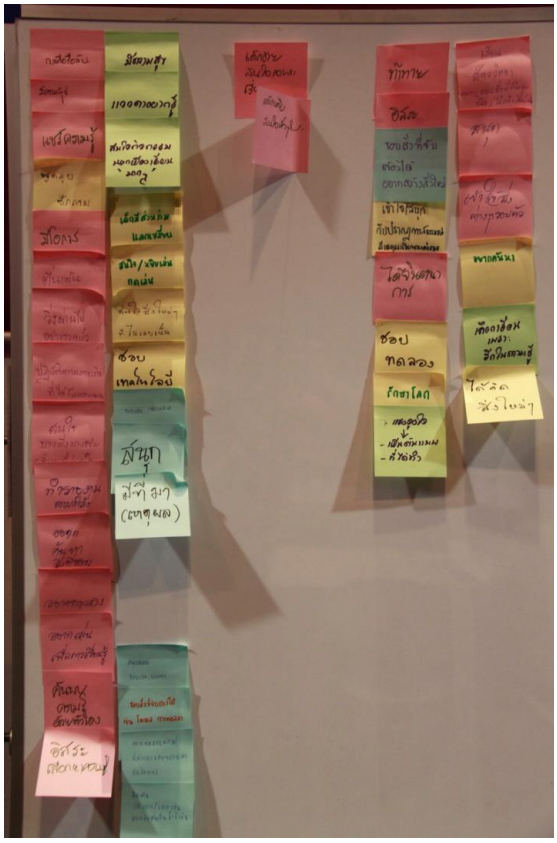
7. Mrs. Ruetai Chongsrid National Science and Technology Development Agency

8. Mr. Prasit Bubpawanna National Institute of Metrology Thailand

9. Ms. Nitima Sripanich Electricity Generating Authority of Thailand

10. Ms. Patthra Srisawat Electricity Generating Authority of Thailand

Images from the morning session:




ประชุมระดมสมองเพื่อสำรวจข้อมูลวิจัยเรื่อง
"บทบาทของพิพิธภัณฑ์และแหล่งเรียนรู้ด้านวิทยาศาสตร์
ในการเตรียมเยาวชนสู่เศรษฐกิจฐานปัญญาและการเรียนรู้"
(Knowledge-Based Economy)

Participants in the Afternoon Session

1. Mr. Niti Boonyakaite National Science Museum Thailand (NSM)

2. Dr. Saowanee Buatone Rangsit Science Centre for Education

3. Mr. Piya Phalakhoj Thasalaprasitsuksa School

4. Assoc. Prof. Dr. Sukanya Sangdean Satit School of Rajamangala University of Technology Thanyaburi

5. Ms. Jirankanya Nabhitabhata True Corporation Public Company Limited

6. Dr. Kritsachai Somsaman National Science and Technology

Development Agency (NSTDA)

**consent letter detailed in Appendix A

STATEMENT	SUMMERY AND CONCLUSIONS	
	MORNING SESSIONS	AFTERNOON SESSIONS
1. We should let children just enjoy science centers, not turn centers into schools.	In agreement because once the children are allowed freedom, they are more eager to learn. They are able to select their own learning methods, enabling self-discovery. In turn; an enthusiasm is gained and can to relay their knowledge to others.	In agreement because once the children are allowed freedom, this results in enjoyment and learning in an entertaining way. They become more interested and enthusiastic in learning. -Since schools have fixed curriculum, the children often become uninterested and unenthusiastic to learn. This differs from their time spent in museums and centers. They become excited and eager to learn.
2. Science centers work better for boys than for girls.	The two genders have different learning behaviors. -Male: Most are interested in spe-cific topics. They prefer using strength and focus on hands-on and moving mech-anisms. Because they wish to learn the workings behind a certain objects, they are prone to attempt disassembling and damaging the exhibitions. Their interest focuses on the presentation over content. -Female: Most prefer to all-rounded learning, taking time to read the descriptive texts. Like males, they are specifically inter-ested in certain top-ics and will become eager when the topics are addressed, but do not use strength. Their interest focus on the content rather than the underlying mecha-nism. Even their learning behaviors dif-fers, but from survey shows both genders learned the contents at similar level. *Side Notes: Most agree that sci-ence museums and centers should re-con-sidered the exhibition design suitable for both genders. NIMT representative believe in designing exhibitions fo-cused on one gender.	The two genders have different learning behavior. -Male: Most prefer hands-on and will play with the exhibition before read-ing. They enjoy spending their phys-ical power and engage in practical practices using their creativity better than the girls. Innovative thinking and curiosity are at higher level than the girls. They like to explore and find the workings behind the exhibitions. -Female: Often read the instructions before interaction with the exhibi-tion, they prefer gentler approach and avoid being upfront.

11. South Africa

Authors: Anthony Lelliottand Michael Peter

Introduction

1.1. List of national contributors:

3 participants from each "stakeholder group" identified by the ASTC were invited, comprising *representatives from corporations*, *science communicator professionals from science centers* and *science teachers*, took part in the focus session. A single focus group was conducted in November 2014 in Johannesburg.

1.2. Executive summary

Brief text with the main results from the focus groups

National Policy on STEM Education and the Role of informal learning in SC

1.1. STEM education has been adopted by the Department of Science and Technology (DST) as a strategy to increase the pool of talent feeding into these areas of scarce skills. The DST has also signed a bilateral agreement with the Department of Basic Education (DBE) and this agreement recognizes the need to focus on STEM education as a priority. Over the last 15 - 20 years science centers in South Africa have been recognized by the DST and by the DBE as important partners in the drive to enhance STEM education in SA. The DST also has SAASTA as its delivering agency, and this organization receives DST funding to manage many STEM education programs. Much of this funding is channeled to science centers and the result is a range of well managed and well supported programs such as: National Science Week, Astronomy Week, Astro Quiz, as well as various exhibitions, competitions including the Olympiad. The science centers also apply for 'programmatic support', that is, funding to support specific programs in areas of need in the communities that the centers serve. There are even programs that support the schools directly, enhancing teaching of the curriculum.

1.2. There is a vast array of programs. The most common ones are those for which there is financial support. National Science Week (NSW), for example, is a major program of the DST and every science center across the country is involved in delivering this program. It focuses on areas of STEM strength in the area in which the science center serves and will include an expo in which various industries and the academia showcase their work; also on show will be talks by role models, workshops, demonstrations, shows and competitions. Focus weeks are particularly popular with science centers designing programs for events such as Earth Science Week, ICT Week and Math Week. These weeks are often very similar in character to NSW, though they are scaled down versions of it. Owing to the performance of many schools in South Africa the science centers have identified a need to support teaching and learning and they thus engage in many programs that directly support the curriculum. Saturday school classes and after hours classes abound, and many centers even go into the classroom to assist teachers with particular topics that the teachers are not very competent in. The science centers in SA do not have a high turnover of fresh exhibitions so they compensate by delivery a range of activities for schools and the general public. These include science shows, dramatization, demonstrations and workshops. Many centers have introduced science clubs and electronic clubs and these manage to attract the same young people back to the center so that they develop a range of competencies in a particular field.

1.3. Definition of terms and acronyms used

- Astro Quiz A national quiz focusing on school students' knowledge of astronomy
- DBE Department of Basic Education
- DST Department of Science and Technology
- ICT Information and Communications Technology
- NSW National Science Week

- Olympiad A national quiz testing school students' knowledge of science
- SAASTA South African Agency for Science and Technology Advancement
- STEM Science, Technology, Engineering and Mathematics

Outcomes of the focus group

2.1. Introduction

When they were invited, the participants were sent an information sheet describing the project, as well as consent forms. They were not, however, sent the statements in advance. Prior to starting, the project was further explained; the statements were handed out, together with explanation of the term soft skills. Participants were given about 3 minutes to read through the 11 statements and explanation.

2.2. The 11 statements used

1. We should let children just enjoy science centers, not turn centers into schools.

2. Science centers work better for boys than for girls.

3. Schools can learn more about teaching science from science centers than the other way round.

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

5. Science centers rarely focus on the relationship between science and industry.

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

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

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.

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.

10. Visiting a science center has little impact on whether students follow careers in STEM.

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

Conclusions

3.1. Conclusions per statement... (Summarizing two or three focus groups)

There was consensus among the representatives on the following statements:

#1: science centers should not take on the role of schools. However, the varying quality of school education in South Africa means that certain aspects of schooling (particularly practical work) can be taken on. The lack of resources within many schools was noted as a concern.

#3: all representatives agreed that schools can learn more from science centers than vice versa.

#5: the consensus was that they considered that SCs do (at least they try to) relate science to industry.

#6: there was general agreement that students do acquire skills in science centers which are highly beneficial for their lives after school, particularly from 'extended programs' rather than one-off visits.

#8: there was general agreement that soft skills can be achieved via other activities; not all of the skills listed are 'science-specific'.

#9: there was general agreement that soft skills should be taught throughout life; they are acquired from personal learning which can happen anywhere.

There were different opinions regarding statements 2, 4, 7, 10 and 11.

#2: the participants did however agree that the possible gendered nature of SCs is a societal issue and that SCs can assist with counteracted gender bias.

#4: the teacher representatives considered that SCs should promote careers, while the other two groups suggested guidance and awareness rather than promotion.

#7: this topic needs more research. SCs do what they can but there is a very great need for innovation and creativity in South Africa which they cannot meet.

#10: this topic also needs more research. There are numerous factors which impact on whether students follow careers in STEM.

#11: the role of the SC is to plant a seed of interest rather than "invest in learning processes with real long term impact". There were different opinions, as the term "real long term impact" was unclear.

3.2. Advantages of informal learning in science centers and museums

The science centers are able to support STEM activities in very creative and innovative ways. Whilst they respect the school curriculum they are not bound to it in any rigid manner. The centers are thus able to integrate different subjects or bodies of knowledge and to expose participants to knowledge that sits outside of the curriculum. This means that participants can be exposed to the the very latest innovations or discoveries and there interest in current events can be ignited and sustained.

The science centers also do not focus on assessment - students have no fear of passing or failing. This allows for learning in a relaxed and unthreatening context which often assists with sparking interest and passion in STEM.

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

Whilst some of SA's science centers are better off than others all of them will indicate thattheir greatest challenge is funding, or the lack of it. Many of the centers have grand plans but very few are able to realize these.

The other challenge that seriously affects all science centers is that of human resources. It is difficult to attract the kind of talent that is needed to generate and support the kind of programs and activities that the centers need to make them relevant and viable. Often managers spend much time training new, and old, staff - only to find that they move on to other jobs. Indeed, training is an ongoing activity for science center managers.

Another challenge is the inability to generate new exhibitions on a regular basis. The costs are prohibitive and this means that the centers are not refreshed at a rate that will generate ongoing interest from the communities they serve.

4. Recommendations

Science Centers in South Africa enable students to acquire skills which will be on benefit to them after school. Centers should aim to be one of the sources of soft skills for students, but such skills can be acquired throughout students' lives.

Science Centers in South Africa should not attempt to take on the role of schools, but, in the unique context of the country, they can provide opportunities for students not available to them in schools. Schools should be encouraged to emulate aspects of science centers, such as their improvisation of equipment.

Science centers need to consider how they relate to industry, and in what ways they should make students aware of careers they might follow.

Science centers should continue their role of stimulating learners, rather than attempting to provide learning with long-term impact.

Anthony Lelliott

Michael Peter

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