

A Cross-Case Study: Comparing the Role of Science Centers in Advancing Scientific Knowledge in Turkey and Denmark

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Şahin İdin^{1*}

¹The Scientific and Technological Research Council of Turkey, Ankara, Turkey

Corresponding Author: *sahinidin@hotmail.com

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Abstract

This study aimed to investigate the role of science centers in advancing scientific knowledge. To do so, two heads of science centers were selected to perform interviews, one of whom had previously worked as a head of science center in Denmark and the other of whom had previously worked as a head of science center in Turkey. The study's approach was modified as qualitative method, and the study can be thought of as a case study in this context. As a data collection tool, a semi-structured interview form was used. It was used to find out what the participants thought about the role of science centers in advancing scientific knowledge. Participants emphasize the importance of science centers in achieving effective science communication. This research is expected to guide future studies on the advancement of the scientific knowledge.

Keywords: Science Centers, Scientific Knowledge, Turkey, Denmark

INTRODUCTION

The importance of science has been increasing in the changing and developing world. Within this context, countries have been carrying out some changes in their science education policies. Technological developments have also been increasing, in parallel with scientific developments. In this sense, technology and its elements have been using in teaching and learning science processes. The teaching and learning science can be carried out in schools and out of schools (Izgi-Onbasili, 2020; Okulu, Oguz Unver & Arabacioglu, 2019; Reid-Griffin, 2019). Science centers may be thought of as informal learning centers that allow access to their visitors (students, parents, teachers etc.)

According to Persson (2000), a science center is any institution providing access to the public for the aim of popularizing science and using interactive exhibition, involving visitor in active experimentation. They target to explain science and technology to society. According to Gilbert (2001), interactive science and technology centers are recognized as potential educational resources since visitors can be made aware of their interests. Zimmerman, Reeve and Bell (2009), science centers are a type of museum that creates opportunities for families to

engage with science through hands-on activities, interactive exhibits, and real experience with scientific phenomena. Şentürk (2015), defined science centers are one of the informal environments that promote science learning and they are still underutilised by formal schools within the context of science education.

Beside science centers, there are more teaching environments such as science museums, planetariums and zoos. Falk and Storksdieck (2005), stated that 12 factors contribute to the quality of a museum experience, though the relative importance of any one of these factors might vary between particular visitors and venues such as science centers, planetariums and zoos. These factors were classified under three contexts:

1. Personal context: Visiting motivation and expectations, Prior knowledge, Prior experiences, Prior interests, choices and control
2. Socio-cultural context: Mediation within group social mediation, by others outside the immediate social group
3. Physical context: Advanced organizers, Orientation to the physical space, Architecture and large-scale environment, Design and exposure to exhibits and programs, Subsequent reinforcing events and experiences outside the museum”.

For all these factors it can be said that they are efficient on science center visitors' understanding of science. Bandelli, Konijn and Willems (2009) science centers use exhibitions, events and programmes to inform and engage the public. They are active in the field of science communication which effected public communication of science and technology studies in the late 1990s. Bandelli and Konijn (2012) science centers played an educational role to offer their visitors lifelong learning and informal learning and they are known as significant players in the communication of science to the larger society. Fischhoff (2013) effective science communications inform people about the benefits, risks on their important decisions. Nanotechnology, robotics, nuclear power, genetically modified organism and virus based diseases such as Covid-19, Sars, Mers etc. are a few of today's realities that would have been impossible, without scientific advances. Bruin and Bostrom (2013) also emphasise to inform people's decisions and public debate, scientific specialists at governmental institutions and nonprofit organisations aim to supply understandable and scientifically accurate communication materials. Burns, Connor and Stocklmayer (2003), state even though people might use the term "science communication" as a synonym for public awareness of

science, public understanding of science, scientific culture and scientific literacy, actually many of these terms are generally used interchangeably. Science communication aims to enhance public scientific awareness, understanding, literacy, and culture by building Awareness, Enjoyment, Interest, Opinion-forming, and Understanding of science responses in its participants. Göpfert (2008) defines 13 public understanding of science measures, which are efficient in science communication. Promotion of science museums and science centers are given as one of these measures. Public lectures, scientists' sponsoring, science exhibitions/festivals, and accompanying research are also some items of those mentioned measures. All these efforts are conducted to increase the public's scientific knowledge. These events have been conducted in science centers, as well.

Trench and Bucci (2010) within science education, there should be increasing emphasis on the need to engage students more actively based on interactive, project and inquiry based approaches that point the understandings and experiences which students have. Science centers already use these approaches while doing their activities. According to Aguirre (2014), although, recently expressions like citizenship

education, public engagement, social appropriation of science and social inclusion have been increasingly evoked in science centers, which reflect a major transformation of the science center role and a new involvement within the education and transformation processes taking place in the society they are engaged with.

Significance and aim of the study

It has already been stated that science centers are places where science spreads to the society. In this context, it can be argued that they have an important mission to show the meaning of scientific knowledge. When focused on literature within carried out studies in both science centers and science communication, it is known some studies have been conducted as shown in the Introduction section. There are more than 20 science centers in Turkey; six of them were founded in cooperation with The Scientific and Technological Research Council of Turkey (TÜBİTAK) and municipalities (Çolakoglu, 2020; TÜBİTAK, 2020). The first science center in Turkey was found in 1994, in Ankara, Turkey. Turkish universities and municipalities independently founded others. There are also science centers and science museums in Denmark. One of the biggest of those around is the Europe Experimentarium, which was opened in Copenhagen, 1991 (Experimentarium,

2020). Beside this, the Danish Museum of Science & Technology (DMST) was established in 1911 (DMST, 2020). The existence of these come to mean that both the countries have experience with science centers and museums. So, this study can be mentioned as a new research in this field since it was conducted with two head of science centers from two different countries, who are excellent experienced in science centers. It can be claimed that there has not been any study prepared in the scope of this research topics and content. For these reasons, this study has an original scientific value. The aim of this study is to investigate the role of science centers in advancing scientific knowledge. To do this, five semi-structured questions were prepared and these were asked to the participants of the study.

METHOD

General background

In this study, the qualitative research method was used, and within this context, this research was conducted as case study. A case study can be thought as one of the qualitative strategies used in qualitative researches (Yıldırım & Şimşek, 2011). Within this context, interviews were carried out with participants (head of science centers). Interviews were conducted via the semi-structured interview form which was developed by the author. Afterwards, it

was sent to experts related to science centers for examination. After the field experts examined, the interview form was sent to two measurement and evaluation field experts. The interview form was finalized in line with the opinions of field experts. It has five open-ended questions. The semi-structured interview form was used as the data collection tool in the research. Semi-structured interviews were held with participants who voluntarily participated in the study. The interview form was aimed to reveal participants' views of science centers' role in advancing scientific knowledge. Basically, the questions try to find out science centers' effect on the link between public and science learning. All five questions are separately given under the Results section. These five questions were asked to two participants. The interviews lasted approximately 25-30 minutes.

Participants

The study was conducted with two heads of science centers. One of them was from Turkey called P1 in the study. The other was from Denmark and called as P2. The Danish participant's experience in science centers is 35 years and he spent his all-working time in science centers. He used to carry out experiments, science shows, guided visitors for exhibitions, which were in the science center, and finally he was the

CEO of a science centre. The Turkish participant is an engineer and he has seven years experience in science center. Before his directorate process, he used to conduct experiments, science shows and scientific projects.

Data analysis

Interviews were conducted with participants both face to face and via web. Accordingly, the researcher and academicians, expert in their field revealed raw data of the interviews. The field specialists and researchers separated the data into codes first and then, the data obtained from the codes was collected in themes. Two assessment and evaluation specialists to provide validity and reliability. Two experts examined the interview data and themes and codes were formed as independent from each other. The "compatibility percentage" formula was used to determine the reliability of the codes and themes obtained from the interview forms by the two experts (Miles and Huberman, 1994; Miles, Huberman and Saldana, 2014). It was expressed as; $\text{Compatibility percentage} = \frac{(\text{Agreement})}{(\text{Agreement} + \text{Disagreement})} \times 100$. In this formula, the compatibility of the data of two experts is calculated. According to this formula, the compatibility percentage in the transcribed form was found as 94, 62. It is said that if a compatibility percentage

is at 70 or above 70, it can be used (Yıldırım ve Şimşek, 2011), and that value should be above at least 80 % (Miles and Huberman, 1994; Patton 2002).

Ethical issues

Participants were informed about the study in terms of its content, the reason, and period of study, what type of data would be obtained and where they will be used with that purpose was given and which applications would be applied during the study. Participants were also provided to participate in the study voluntarily. Their name and personal

information were not given in the study. Instead, they were just coded as P1 and P2. Within this context, they were given a “Volunteer Participation Form”.

RESULTS AND DISCUSSION

This section is seen accompanying questions of the study.

Results of the first question

What do you think about science centers’ role within the scope of activities that are carried out in science centers?

Two participants answered this question. Their answers are given in Table 1.

Table 1. The Data of the First Question

Code	Theme	
P1	Only 50 years old!	A new kind of cultural institution
	Dislike museums, science centers	Have no collection to take care of and spent time on
	Only communicate science	It is the use of USP of science centers
	Multiple effect	Visitors; get more interested in science and technology, more open to learn S&T
	Teach teachers	To become better science and technology teachers
	Conduct research	How to better conduct science and technology to children, teachers, etc.
	Communicate to society	Available platforms: The Internet, the schools, the universities etc
	To produce Actually instigate	Science news themselves Start-up companies on ideas emerged from research or daily activities in the science center
P2	A bridge	Between science and public to ensure their awareness and understanding basically within scientific studies.
	Science communication as the link	Between science and society society is the most important element of the progress of societies by taking science to the center.
	Increase the interest	Science centers aim to increase of the society to science
	Very effective activities	In terms of science, making science in agenda and encouraging.
	More positive children’s viewpoints	Within the context of scientific issues and what they call complex and difficult.
	Enormous role	Science centers show people via activities how much science is in our lives
more prosperous society	Created by activities in science center	

Nine codes were created by P1's statements and seven were created by P2's statements. Especially, some important codes of P1 are multiple effect, communicate to society, actually instigate, teach teachers. To illustrate his codes, his themes can be looked at: Conduct research, teach teachers and available platforms: the internet, the schools, the universities etc. (relate code is communicate society). To have much more thorough information about this theme all his statement can be given. Science centers also conduct research in how to better communicate S & T to children, teachers, layman etc. on the available platforms: The Internet, the schools, the univeristies etc. Even more,

science centers produce science news themselves. (P1)

Promoting scientific knowledge via science centers creates a bridge between science and public that is to ensure the basic sciences and scientific studies to public awareness and understanding. It can be seen by looking at P2's statement. Science communication as the link between science and society is the most important element of the progress of societies by taking science to the center. (P2)

Results of the second question

Do you think science centers have effects (positive or negative) on visitors' scientific knowledge? If yes, can you explain how? Their answers are given in Table 2.

Table 2. The Data of the Second Question

	Code	Theme
P1	Important role	Visitors have become more interested in science centers during their visit.
	Communication role	Teach teachers to teach better
	Hidden knowledge	Learn something concrete about visited exhibits, but the knowledge of what they learned is often hidden.
	Entertained	Have fun during learning
P2	Business sport	More young people will seek careers in science and technology, which the businesses need.
	Positive impact	On science communication
	Draw the curiosity of society	children through scientific activities
	Scientific activities	Scientist meetings, science interviews, technological and scientific workshops, science camps etc.
	Very positive contributions	Students have fun during their visit to a science center via Scientific activities
	Basic mission of science centers	Science centers make familiar the science world and society.
	Serious changes in positive direction	No school curricula, no unnecessary topics and having fun with class or society at the same time.

Both P1 and P2 state that science centers have positive effect to promote the development of visitors' scientific knowledge. To be able to understand what the meaning of "positive effect" is some codes give us the opportunity to learn such as important role and positive impact (P1) and draw the curiosity of society and very positive contributions (P2). To have much more thorough information on their codes, we focus on the theme. P1 states that science centers have an important role because visitors have become more interested in science centers during their visit. P2 defines positive effect of science centers as they make familiar the science world and society. Both P1 and P2 highlighted visitor's emotions on communication to tell positive effect. Hidden knowledge, entertained (P1) and very positive contributions and serious changes in positive direction (P2) codes are given to reveal science centers' role in science communication.

To explain this situation better, P2's sentence is given below.

Science centers draw the curiosity of society especially that of children through scientific activities. Such as: scientist meetings, science interviews, technological and scientific workshops, science camps etc. performed in science centers, offer very positive contributions.

Another important expression stated by P1 is given below.

Science centers' most important role is perhaps to teach teachers to teach better science and technology!

It can be understood that P2 states that teachers could access their students easily in their class, school and via online activities.

Results of the third question

What activities, applications that are used in science centers, can be mentioned within science communication? Their answers are given in Table 3.

In this question, the researcher wants to learn what tools used in science centers can be mentioned any elements of science communication. Both P1 and P2 highlighted hands-on and minds on. P1 defined his codes as experiments/exhibits that visitors conduct; P2 defined them as experiments/exhibits that visitors conduct. Besides, P1 gives some more examples of activities as elements of science communication such as mix tactile, tangible experiences, tell the whole story, science and technology learning programs. P2 also gives more examples of activities as elements of science communication such as workshops, science camps, science interviews, mechanic interactive, STEAM programs and living and doing activities.

A part of the answer of P2 to this question is given below to be able to better understand his codes and themes.

Scientific exhibition is one of the main activities together with a wide

variety of communication methods such as hands-on, mechanic interactive, monitoring, programming which are commonly used in science centers.

Table 3. The Data of the Third Question

	Code	Theme
P1	Hands on and minds-on An immersing way Virtual reality and Augmented Reality in future Internet	Experiments/exhibits that visitors conduct They use artefacts, living animals, fish, pieces of art to “tell the whole story Developing scientific knowledge with their concrete apps. . Developing science and technology learning programs
P2	Scientific exhibition Hands-on and minds-on mechanic interactive monitoring Workshops, Living and doing activities Science camps Science interviews STEAM programs	Because they are carried out with a wide variety of communication methods. To design, implement and solve problems by practising.

Results of the fourth Question

Do you think science centers provide sustainability of science

communication? If yes, how? Can you explain your thoughts?

Their answers are given in Table 4.

Table 4. The Data of Fourth Question

	Code	Theme
P1	Very important Although science centers only 50 years old! A very high speed To secure a sound Diverse communication	Research in the conducted science communications Research have been conducted to cast light on which applications. Changing our everyday life
P2	Main mission of a science center Effective science communication activity The long-term cooperation Dissemination activities Multiplier effects	Science communication consistently planned and implemented programs With universities are important for sustainability The main mission of science centers in terms of sustainability. The main mission of science centers in terms of sustainability.

In this question, researcher wants to learn how science centers provide sustainability of science communication. When we focus on P1's codes on this question, it can be seen that some codes can be thought as the question's keywords. P1 stated, for instance, although science centers are only 50 years old!, a very high speed, to secure a sound and diverse communication. To get a more though understanding of these codes it may be beneficial to look at his sentence. P2 thinks providing sustainability of science communication can be achieved since it is the main mission of a science center is this. Therefore, some acts such as consistently planned and implemented programs can be done to achieve this target.

A part of the answer of P1 to this question is given below to be able to better understand his codes and themes.

Science centers are very important to provide sustainability and development for the science communication. Since science and technology these years really change our everyday life at a very high speed, to secure a sound and diverse science communication is very important for the future of wealth and welfare for our societies.

A part of the answer of P2 to this question is given below to be able to better understand his codes and themes.

The long-term cooperation with universities is very important for sustainability. Dissemination activities and multiplier effects are the main mission of science centers in terms of sustainability.

Results of the fifth question

What can be done to promote science centers' role in advancing scientific knowledge?.

Their answers are given in Table 5. It can be seen in Table 5 that both P1 and P2 state some common statements for promoting science centers' role in advancing scientific knowledge.

P1's codes are much more dependent on research and government and the fact that communities should be persuaded. When we focus on P1's theme (To really clarify impact of a science center to its many audiences), he highlighted the importance of visitors for promoting science centers' role in advancing scientific knowledge. P2 reveals his thoughts via concrete examples such as science communication trainings, infrastructure strengthening supports, package programs, to get more benefit from universities and academic advisory board.

Table 5. The Data of the Fifth Question

	Code	Theme
	Much more research should be done.	To really clarify impact of a science center to its many audiences
P1	Government and communities should be persuaded.	To accept stronger support for investments and the operation of the science centers.
	Science communication trainings	They can be provided to science centers.
	infrastructure strengthening supports	They can be provided to science centers.
P2	package programs	They can be offered to science centers.
	to get more benefit from universities	Their current scientific studies.
	Academic advisory boards	It can be established in science centers.

A part of the answer of P1 to this question is given below to be able to understand his codes and themes better.

Much more research should be conducted to really clarify to impact of a science center to its many audiences (laymen, school pupils, teachers, media, universities, businesses etc).

A part of the answer of P2 to this question is given below to be able to understand his codes and themes better. *Science communication trainings and infrastructure strengthening supports can be provided to science centers. Science communication package programs can be offered to them. And also it can be opened the way to get more benefit from universities and their current scientific studies. Academic advisory boards can be established in science center.*

It has been found that each participant of the study has mentioned the important roles of science centers in advancing scientific knowledge. Considering this aspect, it is seen that the

opinions of the participants are compatible with the literature that is given in Literature. Participants stated that coming to a science center enhance a student's interest towards science. It can be inferred that science centers are places in which science communication is achieved. There are some studies seen in literature, which have similar results to third question. Hands on minds on activities were highlighted by both participants of the study. Rennie & Williams (2020) carried out a study with people who work in a science center. They found that the science center staff belived some roles for the centers. A science center as an avenue for learning science, leading to a much broader relationship with science, real nature environment, visiting to a science center make some changes to people about their thinking towards science. Schwan, Grajalb & Lewalterc (2014), indicate that after designing exhibits in an interactive hands on manner, visitors can be encouraged to engage constructionist

activities and inquiry-based learning. In science centers, there have been implementing technological activities such as technology-based applications. Beside this, scientific and technological based exhibitions are used to enhance visitors' interest towards science. Bell & Rabkin (2002), believe that to ut a good technology education science centers must prove what technology means and what is going on in technology currently. In this study, also, very similar results have been found that they can be understood by participants' views. Bressler & Bodzi (2013) revealed that Augmented Reality (AR) based science games help to increase science interest and help middle school students' collaboration skills.

As P1 mentioned AR based technological tools will be used more effectively in science centers to provided students more active during their staying at exhibitions and any other places in a science center. Meanwhile, P2 described that science camps, science interviews, workshops, scientific exhibition, living and doing activities, hands-on and minds-on activities and STEAM programs are implemented in science centers within the scope of the second question. Those mentioned activities are being implemented in Kopenhagan science center as P2 mentioned those are also implemented in science centers,

which are located in Turkey. STEAM Education, one of the popular educational approaches, and its applications can be conducted efficiently in science centers to supply students' learning concepts in science and technology. Autio, Hameri & Vuola (2003) remarked in their study that promoting technological learning and innovation benefits only becomes possible when one can understand what causes science centers. Antonioli, Blake & Sparks (2014), state that AR has becomes the mainstream in education and this technology can allow the learning to be student-centered and promote opportunities for collaboration that fosters a deeper understanding of the content. Ateş, Ural & Başbay (2012), implemented their study with middle school students. They investigated students' attitudes and contributions towards the learning process via a developed program which was used in the science center. They revealed that students enjoyed conducting experiments and excitedly attended the activities. Çiğdemoğlu and Köseoğlu (2019) prepared a professional development (PD) program and they investigated the impact of the PD program created for elementary science teachers in order to actively integrate science centers and formal school curricula. They found that this program helps teachers to effectively organize a visit to science centers in order

to back up school learning. There is a similar study conducted to the second question in California Science Center by Falk & Needham (2011) and they found that science centers have an important impact on the science literacy of visitors. Besides, self-report data show that visitors believe science centers strongly influenced their science and technology understanding. In accordance with this, there are science centers to bring science to the people (Feinstein & Meshoulam, 2014). Science centers target to enhance visitors knowledge of science (Davidsson & Jakobsson, 2007). Hakverdi Can (2013) indicated that in order to ensure science centers' effectiveness, education booklets that are going to be prepared by science centers and Faculties of Education should be prepared together. It is worth emphasising again that parents must also be actively involved in activities carried out in science centers. Other important points are involving companies (P2) and business support (P1) to the science centers. If these can be done science centers may provide access more people to popularize science. Both participants did not mention any role of nonprofit organizations. Nonprofit organizations should be involved with the science centers when national and international projects in the field of science communication are conducted. Thus,

science centers may allow the public access to show them basic instruments of science. Storksdieck et al (2016) citizen science is a powerful bridge between a scientific study and the larger society that may benefit from it. So, three different citizen science associations, from US, Europe and Australia improved inter-association collaborations. In line with this, there are some international science centers and associations such as Association of Science and Technology (ASTC), European Network Science Centers and Museums (ECSITE), Asia Pacific Network of Science and Technology Centers (ASPAC) and North Africa and Middle East Science Centers Network (NAMES). Science centers in Turkey can create some common projects with these associations for promoting science communication and its elements. Participants expressed that much more research should be conducted to promote science centers' role in science communication. Within this context in a study conducted by Bamberger & Tal (2008), it was revealed that promoting students' willingness to visit science centers with their family and share their experiences can be useful. One of the important points is to learn the role of science centers in science communication. Dal, Özdem, Öztürk & Alper (2013) stated that science centers might play a key role in improving the

public perception of science, contributing to a positive assessment of science and its technological based developments. Irwin (2014) states, science centers should not mainly aim at persuading young people to embrace science and technology in a rather unquestioned way, but rather support them in becoming reflexive members of contemporary knowledges societies through caring for broader science-society issues. Thus, they can help people to understand scientific concepts which they may face today or in the near future. To be able to promote the role of science centers some thoughts were given by head of science centers related to the fifth question as seen in table 5. To do this, package programs, to get more benefit from universities and science communication programmes can be used according to participants. Köseoğlu, Tahancalıo, Kanlı & Yılmaz (2020), revealed that Turkish teachers, who had participated in their research, were aware of the high educational value of the activities carried out in science centers and they also demanded provision of inservice training activities for science centers. In the findings of that study, it can be seen that teachers think prioritize the issues that should be included in the professional development package which enable it to more efficiently use of opportunities in science centers.

To be able to promote science centers' role in science communication, P2 mentioned that universities to get more benefit from universities. It is seen scientists, who work in Turkish universities, create scientific projects related to science centers and that they apply for funding programs at national level such is to TÜBİTAK. They can also apply for international programs related to science communication including science centers such as the European Comission Programmes.

CONCLUSION

Science centers help society learn scientific knowledge effectively with its elements and activities. As a result of this, science communication elements are implemented in those places. Science centers can do their best for promoting science to the public. To do this, they can restructure themselves and pay attention to 21st century skills. It is expected that this research will lead to future studies to be carried out in science centers within the scope of further development of scientific knowledge. This study was conducted with two experienced head of science centers. Future studies can be carried out with more experts and visitors to the science center. Due to pandemic, science centers could not be visited to observe scientific activities which are carried out in these science centers. Researchers can also observe

scientific activities, that are carried out in science centers, in their future studies.

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