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The Austrian ScienceCenter-Network as an example for systemic intervention in science learning

Abstract: *The Austrian Science Center Network serves as an experimental setting for putting network theory into practice. It aims at stimulating systemic interventions in various societal subsystems by fostering hands-on science learning. The paper analyses the structure, instruments and outcomes of this organisation during its first decade.*

1 Introduction

If scientists, museum educators, artists, teachers, science communicators and policy makers engage in lively discussion and open exchange even at the 58th network meeting – then something must have worked out in the Austrian ScienceCenter-Network. If 170 partners from such diverse institutional backgrounds focus on their common active interest in hands-on science learning and, without formal commitment, stay engaged and willing to learn and cooperate – then the network must provide some value to them. If the initiators of the Network[1] look back at the first 11 years – they smile. In retrospect, it seems straightforward to put network theory into practice for a systemic intervention – however, it started as and still is an ongoing experimental process, requiring careful observation and governance. This paper intends to analyse the structure, instruments and outcomes of this unusual organisational form.

For many of the challenges our society is facing, the attitudes we have towards learning as well as towards science and technology are key elements for change. The underlying idea of science centers and their activities is that self-determined, playful and interactive engagement with science and technology can spark fascination and interest, can be empowering to their users and can foster a joy in learning. If these prospects hold true, we have to make use of the full potential of

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1   i.e. the founding board members of the non-profit Association ScienceCenter-Netzwerk: Margit Fischer, Josef Fröhlich, Wolfgang Czerny, Monica Stadler, Barbara Streicher.

science center activities for societal benefit. This touches on the needs of several societal subsystems: The innovation system needs (young) people interested in science and technology careers from all socioeconomic, educational or ethnic backgrounds as well as gender. In the education system, the shift from knowledge to competences goes along with a need for self-determined and practical learning experiences. In all areas of our society, being able to critically question and understand, to engage in dialogue and to reflect on science and technology issues that affect our lives, are important competences and elements of a mature democracy.

Table 1: Key questions driving the Association ScienceCenter-Network

How can we inspire young PEOPLE to pursue science or technology careers?
How can we support joyful LEARNING for all ages?
How can we tap into the POTENTIAL of all people in a globalised science and economy?
How can we foster SOCIAL INCLUSION in a fragmented society?
How can we induce DIALOGUE about complex topics?
How can we value SCIENCE as part of our culture?

Table 2: Science Center Activities – as defined within the Austrian network

engage laypeople so they may experience and understand scientific topics, technological phenomena and connections between them
– are interactive (hands-on or minds-on)
– enable self-determined learning
– do not presume prior knowledge
– have a playful component
– give impulses to think further

We believe that open learning environments, as provided by science center activities, can positively contribute to these challenges. This led us to look for a matching organisational form that in itself would represent an open learning environment, which supports insights about and broader implementation of science center activities. Stimulating such implementation processes in the Austrian learning landscape requires an understanding of complex systems.

2 Structure

2.1 Principles of complex systems

In a complex system, the components interact in a way that is non-trivial and thus cannot be predicted by standard linear equations. Self-organisational processes of its actors, as well as small variations in initial conditions or (external) interventions, will influence the time-dependent changes in the state of the system. Its overall behaviour can thus only be understood as an emergent consequence of all embedded behaviours, as the whole is more than the sum of its parts (Levy 1994).

Social Systems Theory (based on Niklas Luhmann 1984) identified three key principles that are at work in complex systems: self-organisation, self-production and requisite variety.

The capacity for self-organisation is a property of complex systems which enables them to develop or change internal structures spontaneously and adaptively in order to cope with or manipulate their environment (Cilliers 1998). This principle implies an openness of the system, so that it exchanges resources (energy or material) with its environment.

Self-production (or autopoiesis) is the capability of a system to reproduce and maintain itself (Maturana 1980). It develops own behaviour, rules and communication patterns, which shape its identity. In complex networks, governance is a matter of autonomous self-control and not top-down steering from a central position (Little 2001). This principle implies autonomy of the system to keep it stable and alive.

Requisite variety is necessary for a system to deal productively with perturbations, e.g. from the environment. The larger the variety of actions that is available to the system, the larger the variety of perturbations it is able to compensate (Ashby 1958). This principle implies that diversity of actors in a system is needed to be optimally prepared for any contingency.

Networks are ideal models for the description of complex systems, as they show similar structures and features. An autopoietic social network is as a set of organisations or individual actors which interact non-trivially and come from various societal subsystems. Although those subsystems remain autonomous, the social network has the potential to orient and transform them through the self-organisational and reorientation processes of its actors that are stimulated through participation in the network.

In terms of organisational learning that fosters social innovation, networks have been found appropriate and useful structures (Willke 2004). However, they need a social entrepreneur taking the risk of founding and operating reflection

spaces in order to pool actors within "cultural islands" (Schein 2010) focusing on social innovation (Wilhelmer 2012). Such guided networks are able to become "change agents" within civil societies by offering free space for entrepreneurship, organisational and network learning. They build on system dynamics and illustrate that complex organisations have no single optimum, but different optima in different times (Forrester 1971).

3 Setup of the Austrian ScienceCenter-Network

For the idea of stimulating interactive hands-on learning in the Austrian (science) learning landscape – which touches on subsystems such as education, science, innovation, museums, arts, policy, economy – initiating a social network seemed a valid experimental approach: it could generate the intended impact and at the same time serve as a practical test of network theory.

The Association ScienceCenter-Network Austria was set up mid-2005 as a non-profit entity. In January 2006, the proponents invited relevant actors to a first meeting, sounding their needs and ideas as well as developing a common vision for the to-be-established network. Immediately, a number of organisations committed themselves and became the first partners of the network.

Inside this (since largely grown) network, the Association fulfils a number of functions which are critical with respect to the steering of the network, also keeping the above-mentioned principles of openness, autonomy and diversity in focus.

Firstly, it operates as a hub that provides orientation and organisational functions and serves as a contact point within the network, for partners as well as for individuals and institutions from outside. Over the years, the Association has also gained international reputation and is a well-respected entry point into the Austrian science engagement and education community.

A second function is creating learning environments, thus deliberately providing interventions that can mobilise and orient the self-organisation processes of partners. Such interventions include activities, events, projects and processes that invite participation, as well as documentation, research and trainings that invite reflective practice.[2] The Association reacts to weak signals that show potential and then initiates interventions or irritations, which can be regarded as experimental triggers that might or might not be taken up by the partners. It looks out

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2   The Association also undertakes projects and research on its own. The guiding principles for these are not to act in competition with partners, but to go for edgy activities that push the field and to care for the overall benefit and learning of the network by providing access to the results and processes that have been developed.

for a resonance to issues and interventions within the network as well as beyond, including financial donors, in order to let go of or to reinforce topics and issues.

The third function of the Association is network governance, thus continuously and reflectively observing the development of the system, which in this context is regarded as the network, its actors as well as its environment, both nationally and internationally. This includes listening into discussions, observing trends, conducting social network analysis, as well as developing and testing instruments and formats within the network.

3.1 Network governance

Orienting and supporting a social network relies on a set of characteristics that can shape network culture. Among these are ensuring cooperation, confidence, commitment, reliability, negotiation, sustainable partnerships and systematic insights. Within the Austrian ScienceCenter-Network, the Association actively uses this advice deduced from network theory to build the principles and instruments within the network.

From the start, the Austrian ScienceCenter-Network proved to be a structure unfamiliar to many actors in the field. It is not a membership organisation, not a federation nor an umbrella organisation. Instead, it is a deliberately non-hierarchical structure, even though the Association assumes a central role. All partners maintain their independence and self-organisation and they do not have to pay any fees. Partnership, however, does require a commitment of the respective partner, for genuine interest in science center activities, for openness in sharing, as well as for participation in activities of the network if adequate. An unusual, but proven feature of the network is that partners are not actively recruited for the sake of completeness of actors. Hence, only truly interested individuals or organisations seek out partnerships and thus account for an active network.

This special structure in itself influences the culture within the network. It remains an open structure, as partners themselves define their interest and participation as adequate. This is well reflected in the resulting high diversity of partners, with regard to their expertise[3], size, as well as their geographical location. The structure enables fairness as every partner is considered of equal value, no matter if it is an individual person, a small organisation or a large institution, differences are being respected. Giving and taking are important values, as the benefit of being a network partner is dependent on his/her engagement and sharing. No formal

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3   The more than 170 partners can be grouped into categories of museums, (science) communication, research, education, economy and arts & media.

decision-making processes are required within the network, yet, the Association listens closely to the upcoming issues and trends, with a view to the overall benefit of the network. This allows great flexibility and the ability to react quickly to new ideas, opportunities and requests. At the same time, it requires trust, commitment and participation from everyone who wants to shape the course of the network.

The structure of the network, thus corresponds closely to its main content focus: Just as science center activities provide a rich environment for self-determined personal learning, facilitated by explainers, so the network, facilitated by the Association, provides a rich learning environment for self-organisation of partners. In both, active engagement based on individual preferences and conditions is the key to learning, making connections and change processes.

A special governance element, unique to this network, is the very active involvement of a chairperson with high societal reputation, Margit Fischer. Being the wife of the Austrian President[4], her prestige greatly supports the confidence and reliability ascribed to the network, while her long-term engagement and expertise in the science center field, coupled with her open and modest personality, exemplifies commitment and communication style for the network.

4 Instruments

4.1 Network meetings

Frequent network meetings are the most important instrument within the Austrian ScienceCenter-Network. Those regular physical encounters – which are possible due to the limited size of the country – form the basis for connections between actors, for a common understanding of issues and goals around interactive hands-on learning as well as for establishing network culture.

During the first 11 years, 57 network meetings took place, each with an attendance of 40–80 participants. All network meetings are open to guests (usually 10–20 % of participants), ensuring the openness that is required for self-organisation of a social network.

The character of ScienceCenter-Network meetings also reflects the principles of open and interactive learning that are at the heart of science center activities, which are the common interest of partners. Characteristic features of the network meetings thus include an appealing setting, interactive, sometimes playful formats, small group discussions and professional moderation. Hence, engaging with the topic and with each other feels essential and natural for participants,

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4   Dr. Heinz Fischer, Federal President of the Republic of Austria 2004–2016.

they easily develop connections and confidence. The now well-established format that supports open-minded exchange and learning also serves as an element of reliability and commitment within the network. By carefully documenting the issues and discussions of network meetings, the Association ensures that even those partners that could not participate feel involved and informed about network developments.

Network meetings take place five times a year, twice a year outside of Vienna, usually at a partner's venue. This is an opportunity to visit each other and foster peer-to-peer feedback on activities or exhibitions, strengthening confidence and the sense of a learning community. Partners who offer to host a network meeting influence the chosen topic, they show their commitment and thus may become attractive partners for cooperation.

Determining a topic for a network meeting is one of the options for intervention within the network. By highlighting particular issues, the Association provides an impulse and at the same time monitors the resonance of partners with the particular issue. Most topics arise through discussions within the network, by the suggestion of a partner or by scanning national and international trends in the fields of informal learning and science communication. A number of meetings have focused on network development, ensuring systematic insights and reliability. The initial meetings also included important elements of negotiation, resulting in the definition of "science center activities" (see Table 2) and a mission statement for the network (Science Center Netzwerk 2007).

The network meetings build the ground for inventions in the social network that can be seen as emergent phenomena, as predicted by network theory. Among these are project cooperations, events, trainings, invitations, publications, etc., where partners are interacting bi- or multilaterally with each other, often to the benefit of a specific target group or audience.

4.2 Cooperative projects

Initiating cooperative projects inside the network is another important instrument that allows orientation of actors which might then influence their respective (sub)system. By openly inviting participation, partners and other interested organisations can be mobilised to develop content on a specific topic, engage with a particular target group or become more attentive to a certain attitude or principle.

While ideas for projects are often invented and creatively played with inside the network, efficient implementation requires a different structure. Thus, organisationally, a project has to be separate from the regular network activities, with a hierarchical structure and clearly defined goals and roles. Ensuring a balance and

clear distinction between open network processes and efficient project structures proved to be one of the most important learning steps during the development of the network.

Projects and cooperations are emergent phenomena of the Austrian ScienceCenter-Network. They utilise the complementarity of partners' expertises and the trust built up within the network. Large innovative and cooperative projects often involve the Association in the function of project management; additionally, numerous other cooperations have been formed between various subsets of network partners.

Travelling exhibitions are examples of network projects that demonstrate well the scope and vitality of the Austrian-wide network. The three exhibitions developed so far were conceived in network meetings, negotiating suitable topics and formats. Eventually, partners were invited to contribute with their interactive exhibits, which were curated and organised by the Association and a project team into a coherent, modular and robust travelling exhibition. All three were characterised as highly interdisciplinary, hands-on and engaging exhibitions[5]. Partners could participate by providing exhibits, working as a member of the project team (design, text, facilitation, etc.) or by hosting the exhibition in their venues. They profit from having their work shown across Austria, thus gaining visibility, from access to a highly engaging exhibition as well as from reflective discussions around the project and its results. A number of participating organisations were inspired by the project to develop and build their first interactive hands-on exhibits and learned from support and feedback by their peers. Obviously, the largest impact is on the more than 150.000 visitors of the exhibitions, among them a large number of school groups. As accompanying research showed (e.g. Hossein 2008), the interactive, interdisciplinary, open setting was highly attractive and inspiring for students and teachers.

Another type of project intervention includes concerted activities throughout Austria. These mobilise partners to offer public activities on a certain topic during a specific awareness week, sometimes coupled with international events[6]. Publishing this as a network activity strengthens the cohesion and identification with the network and provides an incentive for taking up new topics. An impressive example of a coordinated activity of the Austrian ScienceCenter-Network was the

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5   Erlebnis Netz[werk]e / Discovering Net[work]s (2007–2010); Grenzgenial / Borders and boundaries (2009–2013); Wirkungswechsel / Interdependencies (2014-ongoing); for details on all projects, see www.science-center-net.at

6   Topics for action weeks were, e.g., polar melting, space, mobility or planet under pressure.

participation in the 1st International Science Center and Science Museum Day in November 2016[7]. For this event, hosted in the Natural History Museum Vienna, hands-on activities on each of the 17 UN Sustainable Development Goals engaged visitors in discovering the science and scope of action around these global topics. Again, this event mobilised partners as well as the exchange with the surrounding subsystems, including sustainability actors that became aware of the interactive approaches the network has to offer. Visitors from schools and the general public were highly satisfied and enjoyed the open format that invited self-guided and playful exploration and triggered interesting discussions on the complex global topics.

The opportunity to host the Annual Conference of the European Science Center Network ECSITE in 2016 in Austria[8] was a strong moment of identification for the network. The three hosts[9] invited the other networks partners to shape the conference, especially with a Nocturne event showcasing the Austrian ScienceCenter-Network to the international community. Additionally, a large public event[10] invited network partners, schools, research teams, companies and passers-by to participate in constructing elements for a huge cooperative chain reaction machine. Not only were partners proud to be part of this, they also learned a new format of engaging the public. As the Association ScieneCenter-Network had already gained experience with chain reactions in various other settings[11], it since provides support for partners wanting to transfer the activity into their own specific contexts (e.g. in museums, schools and public events), thus widening access of the public to such engaging activities, inspiring learning for all ages.

Further important project formats included workshops in schools, discussion games as well as action research projects. For example, understanding of inquiry-based teaching in primary schools was fostered when six network partners worked for a year with schools in their vicinity, probing how interactive science learning was taken up by pupils and teachers. The results regarding activities and research were disseminated in the network as well as to the educational system with pub-

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7   In 17 Zielen um die Welt / Around the world in 17 goals (November 10th, 2016).
8   ECSITE is the European network for science centers and science museums. The conference took place in Graz, June 7–11 2016.
9   Childrens museum Graz FRida & freD, Universalmuseum Joanneum, Association ScieneCenter-Netzwerk.
10   „Ecsite for all": more than 90 palettes with diverse chain reaction mechanisms were built, resulting in a 13 minute chain reaction.
11   In holiday workshops with kids & parents, during a walk-in action week, inside the knowledge°room, etc.

lications, an extensive report and a symposium (Frantz-Pittner 2011, IMST 2010, Science Center Netzwerk 2010a, 2010b).

A special project is the "Knowledge°room"[12], which transforms empty shops in underserved areas of Vienna into pop-up science centers, reaching out to non-privileged communities, including migrants and refugees. Partners can use these as experimental spaces to test activities and formats for audiences that rarely visit their museums or activities. This project not only stimulated reflection about social inclusion (see below), it also motivated transfer of the project idea into further contexts. Since 2013, the knowledge°rooms successfully attracted thousands of visitors, many of them from low socioeconomic and migrant backgrounds, serving as a place where empowerment can happen through engagement with science.

4.3 Working groups and transfer

With the steady growth of the network, a need for differentiation became obvious. Thus, a new instrument for more intense discussions evolved in the form of working groups on specific subtopics. Coordinated by the Association, partners meet regularly in order to advance and spread the issues, thereby providing products and processes for the relevant societal subsystems.

For example, the network has worked on developing a training scheme for science communicators (explainers), which has already been put into practice in various seminars and attracted participants from research, museums, universities, education and science communication[13].

With a view to the formal education system, partners have commonly devised a model development plan (Bertsch 2014) for Austrian schools who want to put a focus on science and technology, supporting their self-guided change processes. Schools were also provided with guidelines and resources on how to foster STEM learning (science/technology/engineering/mathematics) and how to make use of the informal science learning field.

A series of meetings on social inclusion in science communication managed to further attract participants from arts communication as well as relevant gatekeepers and members of migrant communities who are interested in building contacts with cultural and science institutions. Apart from great discussions, valuable contacts and individual cooperations, a result for the public was the development of

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12 Wissens°raum / knowledge°room, since 2013 in Vienna, awarded with SozialMarie Prize for social inclusion 2014.
13 Impulse and advanced seminars on explainer professionalisation, since 2013.

a website for socially inclusive science and arts communication[14]. Currently, this group has joined forces with the European science center community to work on a framework for social inclusion in science centers and museums.

These examples clearly show how the network, with its partners from various societal subsystems, is able to identify, process and condense issues of importance. The results not only influence their own orientation, but through raising interest and deliberate transfer also reach further actors and subsystems. This is especially valuable as changes in systems are only possible by bundles of synchronised measures. Reorientation of the actors inside these systems, each with limited influence, can add up to larger societal effects.

4.4 Public relations and documentation

Visibility of the network and its work is essential for effecting changes in the learning landscape. As instruments for public relations, an extensive web platform, as well as regular newsletters to different audiences, serves to provide information on partners, on science engagement and learning opportunities. More and more, social media like Facebook have become an important medium for exchange and references to current developments and offers, connecting the community also virtually.

Publishing brochures as newspaper attachments is a means of communicating highlights of network and partner activities to a broader public, emphasising yearly topics that could be interesting for societal uptake.

Documentation of network meetings, project and study results, as well as formats and instructions for well-tried hands-on science center activities, is another valuable form of sharing knowledge as well as broadly spreading the principles of informal science learning.

4.5 Research, teaching and consultancy

The network is a learning community. Thus, encouraging reflective practice and supporting professional development within the network and beyond is a constant concern of the Association. An important instrument is conducting or contracting research on specific interactive formats and activities, as well as on their impact on target groups. A number of studies and accompanying research projects have been performed (e.g. Schütz 2009, Hossein 2010, Unterleitner 2010, Schulze 2012, Gruber 2016) and results are being shared in network meetings, workshops or through reports.

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14 www.gemmahin.at, since Jan 2017

Teaching and trainings, offered to partners, schools, museums and innovators, have become a significant means of dissemination about informal learning and hands-on science center activities. This has a strong multiplier effect with a potential influence on the formal education system as well as on science communication as intended by research institutions and companies. Most efficiently, such seminars are offered in cooperation with established teaching and training organisations like (pedagogic) universities or human resource departments.

Recognising their expertise and overview with regards to the Austrian science learning landscape, representatives of the Association have been invited as speakers, discussants and consultants on these issues both nationally and internationally. Again, this expertise is rooted in the constant exchange with partners and careful observation of the relevant subsystems and provides an opportunity for impulses that might stimulate re-orientation processes.

5 Outcomes

5.1 Network development

In the 11 years since its foundation, the network has grown to more than 170 partners Austria-wide. While in 2005 no dedicated science center existed in Austria, in 2016 a number of organisations were explicitly using the term "science center" to describe their offers[15]. Additionally, numerous other partners work with science center activities, yet chose a different name. Among the partners are not only institutions, but also individuals with a high interest in the network that focuses on science center activities, some wishing to remain partners even after leaving their institutions.

Diversity is high inside the network, as it comprises:

– partners from the science center, museum and science communication field, for which science center activities are a central element of their work;
– partners from research organisations and the economy, wishing to communicate their results and processes in a more understandable, hands-on, engaging way;
– partners from educational institutions like schools, kindergartens or teacher training organisations, who appreciate the offers of informal learning locations and the ideas, methods and resources provided by science center didactics;

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15 Inatura (Dornbirn), Haus der Natur (Salzburg), EXPI Science Center (Gotschuchen), Experimentarium (Hartberg), Welios Science Center (Wels), Audioversum (Innsbruck).

- partners from arts, design and culture, who work on the border of science and arts;
- partners from the media, who communicate about science (learning).

The overall development of the network has been described as five phases: preparation, build-up, development, reflection and diversification phase (Wilhelmer 2011, 2012). In the first five years, two external counselors[16] with expertise in systems theory and organisational development supported the conceptual design, meta-reflection and co-facilitation of network meetings with dialogue-oriented methods, thus supporting a "soft government" approach and training on the job for the network executive manager (Wilhelmer 2012).

Financing of the fundamental network functions as performed by the Association ScienceCenter-Network as well as for specific projects has been provided by public sources (federal ministries, provinces, cities), social partners and industry associations, by companies, donors, as well as through European projects.

5.2 Network analysis

In order to gain systematic insights as a basis for network governance, social network analysis has been periodically conducted to assess existing connections between partners. The quantitative analysis focused on questions about the structure and density of the network as well as the correlations between the positioning of partners and their activity level within the network. A first insight was gained in 2006 (Heller-Schuh 2006) followed by a comprehensive network analysis performed in 2008/09 (Wenk 2009) and again with a new data set and analysis in 2015/16 (Heller-Schuh 2016).

In accordance with the principle of matching content and format, even the collection of data took the form of a science center activity with reflective potential. Each partner received a set of (80 in 2008, 161 in 2015) cards with all other partners, being asked to sort them into known/unknown and send their established contacts back with comments on the intensity of their interaction. This unconventional and engaging method not only sparked discussion in the partners' teams, it also provided high return rates of 81 % and 74 % (in 2008 and 2015, respectively).

In total, nearly 3.000 connections between individual partners were identified, whereby more than 1.300 were classified as cooperations, characterised within this study as having a benefit to third parties.

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16 Doris Wilhelmer, Petra Wagner (Austrian Institute for Technology).

The results of a typical network visualisation are shown in Figure 1. Each node represents a partner, whereby size corresponds to the number of contacts and colours to the organisational type. The position of a node within the visualisation is dependent on its connection to all other nodes, with highly connected actors tending to be more central.

Figure 1: Social network analysis – Visualisation of the ScienceCenter-Network in 2015
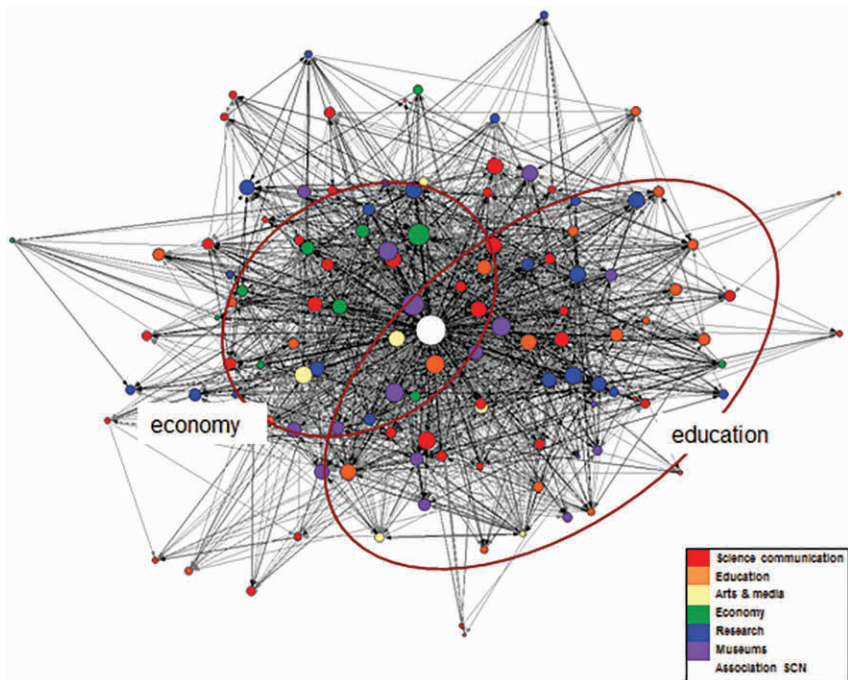
Heller-Schuh 2016

In 2015/16, the Austrian ScienceCenter-Network was characterised by high connectivity and density, with short distances between partners (2–4 nodes) and an average of 20 connections per partner. Unsurprisingly, the Association assumes a central role; however, the network would not be fragmented without this node. There are more connections between actors of the same geographical region, consistent with regional clustering. Partners of similar organisational background also tend to have stronger connections – especially among partners in education and the economy, but less for research, science communication and museums, who seem to serve a bridging function.

Strong correlations were identified between positioning of a partner and his/her activity level in the network. Actors that regularly attend network meetings, participate in projects and trainings or host events show the strongest connections. Multivariate statistical methods and regression analysis confirmed a significantly higher probability for contacts, cooperations and projects among actors if they attended the same network meeting (Heller-Schuh 2016), corroborating the central function of this important instrument for emergent network phenomena.

The analysis of the 1.300 co-operations that were specified further showed a broad range of activities that partners are engaging in with each other: inviting each other as experts for lectures and workshops, interviews and common text production; commissioning a contract; conducting research together; producing an exhibition; cooperating in an activity or event; co-participating in a network project or travelling exhibition; and even forming long-term structural co-operations between partners (Heller-Schuh 2016).

Overall, social network analysis of the ScienceCenter-Network proved the positive effect of several instruments introduced through network governance, both for establishing the weak couplings of knowing one another and for activating them into strong connections of active cooperation.

In 2008/9, a qualitative study was undertaken in parallel to the quantitative network analysis, whereby the researcher interviewed all (then 80) partners of the network. Important findings were the high satisfaction of partners with the network and its offers and benefits for them. Some reported an initial unfamiliarity (and sometimes uneasy feelings) with the non-hierarchical structure of the ScienceCenter-Network. By gaining confidence and showing commitment, however, partners came to regard the flexible structure and open culture as a particular asset of the network. The high diversity of partners was often stated as the most exciting element of the ScienceCenter-Network, allowing fruitful discussions and an insight into different perceptions on issues of common interest. The work of the Association ScienceCenter-Network was commented as central to the drive and development of the network, and as an essential, professional and trustworthy actor with a high commitment to the well-being of the whole system (Wenk 2009).

An important learning outcome for the board and team of the Association was the need to be more precise about the distinction between the network and the Association, as the two share the same name and content focus, yet have very different organisational and decision structures.

The results of the network analyses were shared with the network partners, enabling them to assess their own position by means of ego-networks that high-

light their own connections[17], thus further stimulating self-reflection, as well as to gain insight into systems theory and learning.

5.3 Orienting the network – an example

Among the many issues where interventions were deliberately introduced to trigger self-organisational and re-orientation processes, the topic of social inclusion can serve as a model to describe the effects of the various instruments described above.

Listening to partners and the international discussion was the starting point for the issue of social inclusion to be raised within the network, when a partner shared inspiration from an international conference within a network meeting. Immediately, the Association recognised both the potential of this weak signal and the interest the topic received among the participants. Thus, it dedicated a network meeting (and two more since) to the issue in order to create awareness and sensitivity for the issue.

As an opportunity for experiences, the project "Knowledge°room" was initiated and partners were invited to contribute to the project with content and to use it as an experimental space. From the beginning, this project was accompanied by a social scientist who performed research on the social dimension and the effects of the initiative (Gruber 2016). An event with an open space workshop followed by a panel discussion was set up to publicly discuss the potential that the low-threshold, hands-on science communication offered in local "knowledge°rooms" may have for social inclusion, community work, education and economy. As facilitators and role models in the pop-up science centers, young people with mixed ethnic background are employed, actively using the diversity of competences present in our communities.

A second line of involvement for partners in socially inclusive activities is the long-term cooperation with the Vienna youth prison, which regularly invites network partners to conduct hands-on workshops for their inmates. Additionally, a series of excursions has been offered by network partners to students from the University of Economy who serve as learning buddies for socially deprived youth. Each of those opportunities is disseminated by the Association to all partners, thus periodically reinforcing the idea of social inclusion as a possible focus for their work.

To foster professional development, international experts were invited to present their strategies to empower disadvantaged target groups from migrant com-

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17   Available online at http://www.science-center-net.at/netzwerk_verbindungen/.

munities or low socioeconomic background through engagement with science center activities. A two-day workshop, again with international colleagues, offered professional development for facilitators and partners wanting to extend their skills regarding social inclusion.

The project "knowledge°room" is even internationally one of the few successful attempts of socially inclusive science communication. Thus, results and insights were shared at conferences and events[18] and received high international interest and acknowledgement in the form of invitations for publication (Streicher 2014, 2105) as well as participation[19]. In 2014, the project was entered in a competition and was awarded with the "Sozialmarie", a prize for social innovation. This recognition, as well as asking for funding for the project and thereby illustrating its impact, can be seen as a form of input into the Austrian education and innovation system.

Realising that migrant groups could be more effectively addressed through respected mediators from their own communities, a series of special meetings was initiated. Here, science communication professionals, museum staff, community representatives and non-profit organisations supporting migrants and refugees meet to discuss experiences and ideas on how science and culture programs could be structured and advertised in order to be attractive and socially inclusive. As a result of these meetings, a number of museums and science organisations have initiated cooperations with a cultural translator and/or with community groups, offering special and low-threshold activities for non-privileged groups. A new web platform[20] conceived by this working group intends to bundle and publicise these offers.

The idea of socially inclusive science engagement is also taken up – or the timing coincides with societal developments – by public bodies: Funding calls for science communication which specifically ask for a socially inclusive dimension of submitted projects[21]. As one of the successful submissions, the "knowledge°room" idea is currently being transferred into a different context[22], with counselling by

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18 e.g. Ecsite conferences (2014, 2015), Noyce Leadership Program (2013–2014), EUCU-NET conference (2014), Forum Wissenschaftskommunikation (2015).

19 e.g. in a science festival in Mersin, Turkey (2015).

20 www.gemmahin.at.

21 Support program of the Austrian Ministry for Transport, Innovation and Technology „Talente regional. Kinder, Unternehmen und die Welt der Forschung". Calls 2015/16 put a focus on migrant and diverse social backgrounds.

22 Project "Schau rein!", ARGE WIKI, URL: https://www.ffg.at/sites/default/files/images/ programmlinien/kurzbeschreibung_schau_rein.pdf.

the Association, who is eager to further learn from the experiences with adaptation and feedback the insights to the whole network and its environment. The Vienna business agency explicitly asked the ScienceCenter-Network for trained facilitators to support the city science festival 2015 in their efforts to address and facilitate visits for refugees.

5.4 Reference point and model structure

Within the Austrian education and innovation system, the Association ScienceCenter-Network as the hub of the network has become a reference point and an important input provider. Not only is the term "science centers" now being used as a specific term within public documents, also the network is specifically referred to as an expert organisation and learning community. The team of the Association is frequently invited by media, projects and public bodies as experts for working groups, panel discussions and written contributions on issues around science communication, science policy and education (e.g. Streicher 2014, 2015, 2016).

Additionally, the Austria ScienceCenter-Network has reached a prominent place in the worldwide science center landscape and is regarded as a reliable international partner for cooperations. Its special organisational form is seen as a prototype and interesting model structure for an organisation with very low fixed costs, but a high outreach, diversity and flexibility that is envied by conventional science centers. The network experiment is being carefully studied by international partners (e.g. Becker 2015) and, upon consultancy by the Austrian Association about the structure, experiences and underlying network theory, also being transferred into other contexts[23].

6 Outlook

After more than a decade, the Austrian ScienceCenter-Network is a success story, yet it also remains an ongoing experimental process. With regards to the initial idea of the network serving as a practical test of network theory and social system theory (based on Luhmann 1984), the observations confirm that the key principles of openness, diversity and autonomy are actively cared for by the Association and valued by partners. The advice from network theory with regard to important elements of network governance is being considered and the effect of some of

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23 e.g. Young explorers' clubs, which are organised as a network in Poland – http://www.kopernik.org.pl/en/workshops/young-explorers-club/.

the instruments that have been established based upon it was confirmed by the results of network analysis. Emergent projects and monitoring of developments show an impact, or at least resonance with partners, on visitors and relevant societal subsystems.

The future of a complex system is not predictable. Shaping the future requires a constant and vigilant re-evaluation of internal ideas, goals and processes as well as monitoring of how the overall system develops and a willingness to experiment, learn and adapt.

We will end with two sets of questions that seem relevant to the future of the network:

How can the ScienceCenter-Network keep the balance between being an established and well-trusted organisation and still keep the spirit and momentum of a constantly experimental mind-set? Will it be possible to take the learning network to a next level, by offering it a physical space for reflective practice, without losing the key principles of openness, autonomy, diversity and flexibility?

With the rise of virtual networks with their random nature and constant state of flux, how will the ScienceCenter-Network keep the commitment of partners focused on science center activities? Which instruments will prove essential for stressing the open, yet intentional nature of the network that serves as the basis for cohesion, cooperation and combined strength towards the common goal of stimulating interactive hands-on science learning?

The idea and structure of the Austrian ScienceCenter-Network would never have been possible without the expertise and considerateness of Prof. Josef Fröhlich, co-founder of the Association. We would also like to thank Petra Wagner and Doris Wilhelmer for their support in shaping and analysing the development of our organisation.

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