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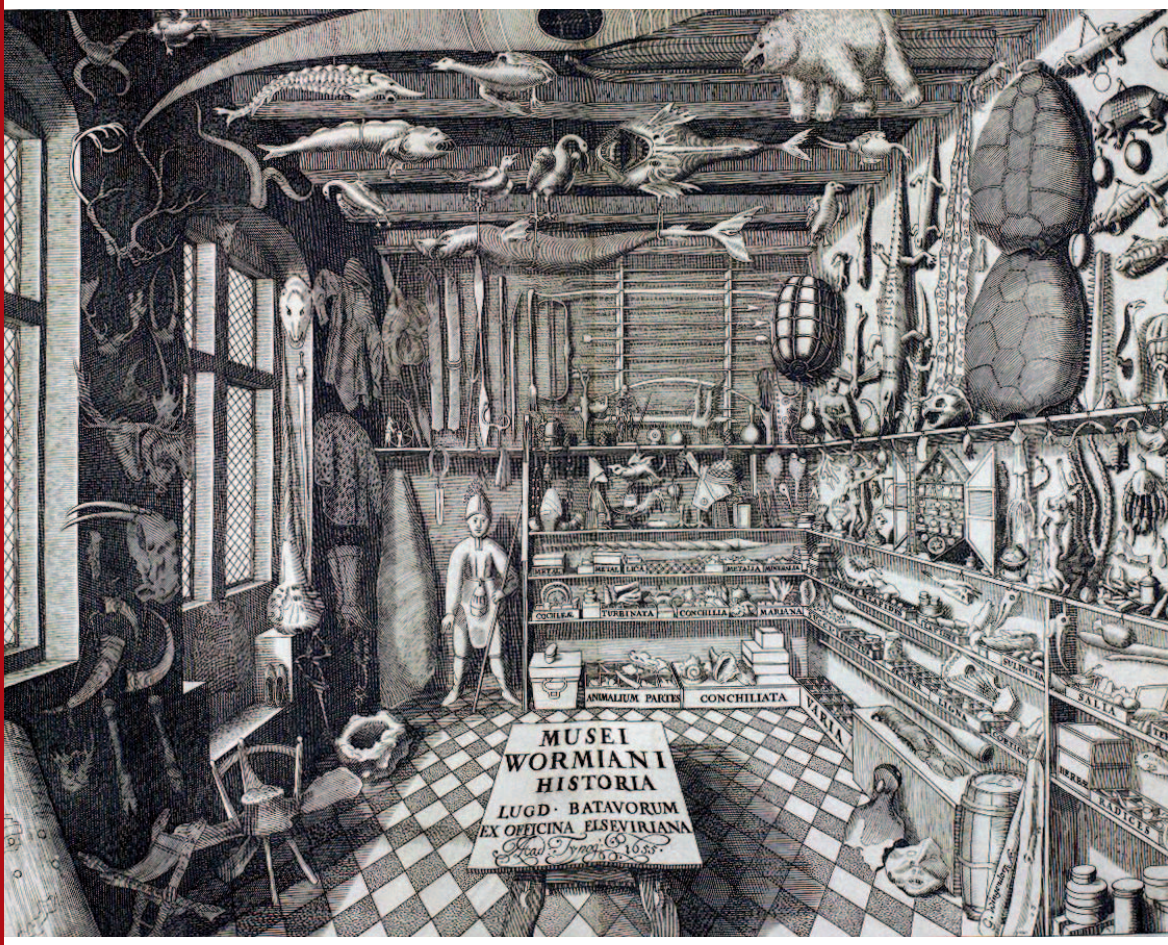
MALMÖ STUDIES IN EDUCATIONAL SCIENCES NO 39, DOCTORAL DISSERTATION IN EDUCATION

EVA DAVIDSSON

DIFFERENT IMAGES OF SCIENCE

A study of how science is constituted in exhibitions



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DIFFERENT IMAGES OF SCIENCE

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EVA DAVIDSSON

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To my dad Bengt, who always supported my decisions in life and followed my work as PhD-student with great enthusiasm and encouragement. Now he cannot share this moment with me.

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1 INTRODUCTION

In 1969, Frank Oppenheimer founded the Exploratorium in San Francisco, one of the first science and technology centres (STC) in modern time. He outlined new approaches to how science and technology could be displayed at a science museum (Oppenheimer, 1968). These approaches involved ways in which visitors by themselves could watch, try and control laboratory equipment and do experiments. He also emphasized socio-scientific issues and displayed interdisciplinary science and technology in ways visitors could recognize from everyday life. Science was in this view not only presented as an isolated academic occurrence, but rather as an integrated subject related to humans' lives and everyday experiences. For example, an exhibition of the human perception could display musical instruments, everyday sounds, the physics of sound, the anatomy and physiology of the ear and technical achievements related to sound and hearing. Oppenheimer argued that these kinds of exhibitions provided an environment where people could become familiar with and gain understanding of scientific phenomena and technical devices. The opening of Exploratorium and other contemporary STCs constituted a starting point for a worldwide movement.

The development of the STC movement can be seen in the light of a time where the US government had lost the space-race against the USSR and was anxious to get the public interested in science. From this societal perspective the STCs could be recognised as a movement with political ambitions (Bradburne, 1998). Another explanation for this development, Hein (2000) argues, was a critique of the ways science traditionally was displayed in natural history or technical museums at that time. Also the way visitors were considered as passive spectators was questioned. In this older tradition, Hein (2000) concludes, there was no in-

tention to popularize science but only commissions to collect and categorize artefacts. The visitors were in general not allowed to touch or interact with the objects. But at STCs, the objects instead aimed to be reconstituted as sites of experiences and the focus was the active and investigating visitor, who was given opportunities to experience and learn contemporary science.

Another possible interpretation of this development is a reaction against the view that science only can be learnt in formal settings or institutions such as schools and universities. This view has its starting point in a number of studies within the science education enterprise which during the decades criticised school science in western countries for being abstract, decontextualized, concept centred, hostile to girls, boring and uninspiring (e.g. Sjøberg, 2000; Fensham, 2000; Aikenhead, 2000; Lindahl, 2003). According to Falk and Dierking (2000) and Rennie and Stocklmayer (2003) informal settings could instead provide a milieu where visitors are invited to study science at their own pace and without any demands of learning about certain phenomena, concepts or facts.

The development of this movement may also be seen in the light of its potentials for contributing to peoples' lifelong learning. As a decreasing number of students, proportionally viewed, choose to study science in secondary school in western countries (e.g. Lindahl, 2003; Osborne and Collins, 2001), STCs serve a purpose when communicating science with citizens without regard to their age, professions, social backgrounds, etc. They also have the goals of bridging the gap between research communities and society and thereby serve as institutions in between current research and citizens' everyday lives. The development of the movement of STCs is in this way in line with other similar phenomena like *Public Understanding of Science* (PUS), *Scientific Literacy* (SL) or *Science for All*, that emphasise the need for all citizens to learn about science.

The movement of science and technology centres

Today, the science and technology centre movement is widespread. For example, the European association European Collaboration for Science, Industry and Technology Exhibition (ECSITE) has over 300 members, mostly European science and technology centers, but also some outside Europe (ECSITE, 2006). The American counterpart Association for

Science and Technology Centre (ASTC) has nearly 450 members spread over the United States and additionally around 100 members from Africa, Asia, Australia and South America (ASTC, 2006). In the Nordic countries the science and technology centre movement is represented by about 50 members of the Nordic Science Center Association (NSCF). The size of these organizations gives an idea of the frequency of STCs in Europe and the United States, but there are, of course, many more in both Europe and the US as well as in the rest of the world that are not members of these organizations.

But what is characteristic about the movement of STCs? The ASTC (2006) states that these informal environments aim to give science a presence in society and to offer people, regardless of age and background, opportunities to ask questions, discuss and explore science and technology through exhibitions and programs. At STCs, visitors encounter hands-on, interactive exhibits and first-hand experiences with scientific phenomena. The goals with such exhibitions are to a large extent educational and the emphasis is to enhance the public's interest in science. Errington, Stocklmayer and Honeyman (2001) argue that museums and centres of all kinds play a key role in the educational infrastructure that facilitates learning of science and technology both in informal and formal contexts. The goal of increasing visitors' interest in science and technology is also an explicit guideline at many individual STCs. For example the board of Experimentarium in Copenhagen, Denmark (Experimentarium, 2007) states that their aims are to enhance the public's interest in science and technology and to highlight scientific methods and results. Similarly, the board of Universeum, Gothenburg in Sweden (Universeum, 2007), states that their mission is to stimulate and encourage young people's curiosity and natural enthusiasm for learning. Yet another example of educational goals for STCs is provided by Barlian Aidid (2001) who describes one part of the strategic plan of the Malaysian National Science Centre as providing an environment as well as facilities for the fun of teaching and learning science.

Science in schools and science in exhibitions

Despite efforts from different movements within science education (e.g. PUS, SL) to increase interest and knowledge in science, surveys like TIMSS (2003) and PISA (OECD, 2004; 2006) instead show that the interest in science is consistently low in most western countries. However,

other studies (Hässler and Hoffman, 2000) provide a more complex view as students express an interest in science concerning explanations of natural occurring phenomena or of practical applications. But when it comes to science as a school subject, students express a rather negative attitude. Also Osborn and Collins (2001) conclude that students think of school science as an important subject, but meanwhile describe it as fragmented, with a lack of discussions and relevance in everyday life. According to these studies, it seems that the problem with the lack of interest in science is not actually related to science as such, but rather to the chosen content and the way in which this content is presented.

In what ways do STCs counter this issue? Pedretti (2002) argues that STCs risk displaying the "wonders of science" i.e. an unproblematic and single dimensioned image of science that shows the good things we humans have accomplished. Also Frøland and Henriksen (2003) and Kostner (1999) support this critique and claim that to be able to enhance visitors' interest in science, museum visits must be of high relevance to the visitors and they argue for the inclusion of socio-scientific issues in exhibitions. This means that visitors could be offered opportunities to become involved in societal dilemmas about for example genetically modified food, stem cell research, discharges that affect the global warming or sustainable development. Furthermore, Pedretti (2004) argues that exhibitions in addition need to consider the potential to stimulate dialogues concerning scientific issues in order to enhance visitors' interest in science. But what is actually displayed in science exhibitions today? Are exhibitions dominated by phenomena-based and concept-centred exhibits? Are socio-scientific issues included in today's exhibitions? And in what ways do exhibitions stimulate visitor dialogues?

1.1 Purpose and research question

Most research within the field of STC does not focus on these issues, but instead concerns visitors' ideas and learning outcomes from exhibitions (e.g. Bishop and Reed, 2005; Falk and Storksdieck, 2005). Many of these studies also explore collaborations between schools and STCs (eg Frøland, 2002; Lucas, 2000). These studies provide valuable knowledge about factors that affect visitors' learning, what visitors do and how they interact with exhibits, peers or curators. However, these studies tend to focus on visitors' learning without considering the displayed

scientific content or sorting out what there is to be learned. This means that today we, to a large extent, have a lack of studies which explore what aspects of science actually are displayed in exhibitions. Furthermore, this means that we have insufficient knowledge about questions such as how do staff members at STCs consider the scientific content and how do they choose what aspects of science to display in exhibitions? What ideas about visitors' learning do staff members express and what consequences follow these when planning and constructing new exhibitions? And in what ways do sponsors affect the content and the design of exhibitions? All these questions highlight the fact that there are a number of different factors which could affect how science is constituted and outlined in exhibitions. Each exhibition can in this way be seen as a result of conscious and unconscious choices made by staff members as to what to include or exclude. The purpose of this thesis is therefore to investigate staff members' assumptions about science and visitors' learning when creating exhibitions and to explore what factors affect the final content and design of exhibitions. The main question running through this thesis is:

- What assumptions and what factors affect how science is constituted and outlined in exhibitions at Nordic science and technology centres?

This question is elucidated and explored from different perspectives, presented in four articles as well as in the different sections in this thesis. The term science and technology centres will be used in a broad sense including different kinds of organisations such as science museums, zoos, aquariums, and other institutions which aim to communicate science and technology to all citizens. Further on, the significance of STCs is used in the same way as Rennie and McClafferty (1996) refer to science centres which are "collections of interactive science exhibits each of which is designed to represent an idea or a concept" (p 57). The authors do not differentiate science from technology as centres usually contain exhibits which concern both science and technology. They argue that research conducted in STCs usually fails to consider possible differences between science and technology.

1.2 Overview of the articles included in this thesis

The following overview presents the different articles in this thesis, the specific research questions for each study and what empirical data material the results are based on. The results of these studies are presented later on. Furthermore, section 2.4 (figure 1) provides an overview of the relations between the research question, hypotheses, data collection and articles.

Article I: Different Images of Science at Nordic science centres
This article, written by Eva Davidsson and Anders Jakobsson, has been published in the International Journal of Science Education, 2007 vol 29 (10), 1229-1244. It focuses on the following questions:

- What aspects of science do staff members display in their present exhibitions?
- What aspects of science do staff members express they would like to display in future exhibitions?
- In what ways do these aspects constitute different images of science?

The data material is based on a questionnaire distributed to staff members at Nordic STCs who work with the planning and construction of new exhibitions at their STC.

Article II: Enhancing Visitors' Interest in Science – A Possibility or a Paradox? A Study of what Scientific Content Staff Members Choose to Display.
The article was written by Eva Davidsson and was accepted to be published in Research in Science Education, January 2008. It focuses on the following question:

- In what ways do staff members consider what scientific content and what aspects to include when planning a new exhibition?

The empirical data consist of interviews with 17 staff members who are responsible for the planning and construction of new exhibitions at 11 different Nordic STCs.

Article III: Staff Members' Ideas About Visitors' Learning at Science and Technology Centres

This article was written by Eva Davidsson and Anders Jakobsson and was accepted for publication in August 2007 and pre-published online (iFirst) in October 2007 in International Journal of Science Education. It focuses on the following questions:

- How do staff members reason about visitors' learning when interacting with exhibits at STCs?
- How does staff members' reasoning intersect with and relate to existing theories about learning within the field of STC research?
- What references of knowledge do staff members refer to when reasoning about visitors' learning and the natural science content?

The empirical material consists of interviews with 17 staff members who are responsible for the planning and construction new exhibition at 11 different Nordic STCs.

Article IV: Economic Interests and Science Exhibitions – A Study of how Sponsors May Affect Exhibition Content.

This article was written by Eva Davidsson and Helene Sørensen and was submitted to Curator in February 2008. It focuses on the following question:

- In what ways do staff members experience sponsors' influence as to how science is constituted and outlined in exhibitions?

The article is based on empirical data from questionnaires answered by staff members who work with the planning and construction of exhibitions at Nordic STCs, participating observations and a focus group interview at one Nordic STC.

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2 POINT OF DEPARTURE AND METHODOLOGICAL CONSIDERATIONS

An important point of departure for this thesis is the use of a sociocultural approach or perspective on humans' learning and actions. This approach originally derives from the culture-historical framework of Lev Vygotsky (1929; 1978; 1986; 1987) where a central idea is that the learning processes and our thinking originate from the social and cultural interactions we are exposed to everyday through encounters with others and our environment. Central to this perspective is what Wertsch (1991, 1998) describes as the irreducible tension between the mind and the mediational means. This means that thoughts are mediated and influenced by humans and cultural products embedded in the tools (e.g. computers, books, symbols and scientific concepts) we use in our environment. Simultaneously as we increase our understanding of how a tool may be used, our thoughts are driven and develop our learning. Kozulin (2003) distinguishes human from symbolic mediators as different mediating agents or means. The human mediators are the people we encounter in a social interaction and refer to how conversations and actions affect and develop our thoughts. Symbolic mediators refer to different tools and signs. From a sociocultural perspective, it is thus not possible to understand a person's learning and actions without considering how they interact with the mediational means or tools and signs they use. Säljö (2005) argues that if we limit our understanding about human thinking and learning to only focus on what happens within the individual, we lose our understanding about how all the cultural products, put at our disposal, affect our thinking and actions. From this view, learning

as well as dialogues and actions are seen to be situated in certain contexts and dependent on social interaction with others and available cultural tools and signs.

The choice of using a sociocultural perspective brings consequences to the work of this thesis. First, it affects the methodological approach when planning and conducting data collection. According to a sociocultural perspective, dialogues and actions are thus situated in certain contexts or discourses (Säljö, 2005; Wertsch, 1998). This implies that the methods to collect data should strive to approach the staff members' dialogues, considerations and actions when planning new exhibitions, in order to reveal underlying assumptions and factors that affect how science is constituted and outlined in exhibitions. This was done successively, during three years, using different data collection methods and is described later on. Second, a sociocultural approach brings consequences as to how it is possible to understand and describe how science is communicated at STCs. This aspect is discussed in section 3.3, *Learning and informal settings* and in 5.4, *Conclusions and implications*, in an attempt to outline a model of how this theory can be used, as well as to understand visitors' learning and development when attending an exhibition.

2.1 Obtaining a general view of how science is constituted in exhibitions

As described in the articles Different Images of Science at Nordic Science Centres (Davidsson & Jakobsson, 2007) and Enhancing Visitors' Interest in Science – A Possibility or a Paradox? (Davidsson, accepted) as well as in section 3.1, *Research within the field of science and technology centres*, in this thesis, there is an ongoing debate within the STC research community about what scientific content to include in exhibitions in order to increase visitors' learning and interest in science. Most of the empirical studies, within this field, mainly concern visitors' perspective such as investigations about what they learn or their attitudes towards science (e.g. Bishop and Reed, 2005). According to Anderson, Lucas and Ginns (2003), these studies seldom refer to or sort out what there is to be learned from exhibitions or what ideas about science exhibitions convey. This means that we have insufficient knowledge about how science can be outlined and displayed in exhibitions. Because of

this lack of empirical studies and in order to attempt to answer the main research question, it was necessary to obtain a general view of how science is constituted and displayed at all Nordic STCs. Therefore, the initial study aimed at exploring staff members' ideas about the extent, to which different aspects of science (Davidsson & Jakobsson, 2007) were represented in their exhibitions, as well as to investigate the extent to which they would like to display these aspects in future exhibitions. For this reason, a quantitative approach was chosen and a Web-based questionnaire was sent to staff members at 47 Nordic STCs, which in December 2004 were members of the NSCF. In all, 88 staff members, who worked with developing and creating new exhibitions, received the questionnaire and 66 respondents from 30 different STCs answered.

This methodological approach was however not in line with the intentions of using a sociocultural perspective as it did not consider the staff members' dialogues, considerations and actions when planning new exhibitions. However these circumstances were considered through the use of successive data collection including different methods. At this phase, an observational study at a single STC could have risked only focusing on peripheral issues, and thereby not being able to describe a general view of how science is constituted and outlined in exhibitions. Therefore the questionnaire of this study concerned statements about different aspects of science, but in addition comprised statements and questions about the staff members' own ideas about science, about sponsoring and background variables (Appendix I). A problem related to investigating people's ideas, values and attitudes about a specific issue in a survey is social desirability. According to McMillan and Schumacher (2006), this means that the respondents tend to answer questions according to what is socially accepted, rather than actually answering in agreement with their own views. This concern required specific demands on how to formulate the questions. One way to improve the questions in order to circumvent social desirability was to test the questions before the distribution to the respondents and this was done through a pilot study. The methodological considerations concerning this study are described in detail in the article Different Images of Science at Nordic Science Centres (Davidsson & Jakobsson, 2007).

The analysis of the questionnaire involved both descriptive statistics and a factor analysis (principal component analysis and orthogonal rotation Varimax) which is thoroughly described in the article. The aim was

to reveal hidden interrelations between the different aspects in the data material. The results of the study highlighted the fact that depending on what aspects of science staff members choose to display in exhibitions, these constitute different images of science. Further on, the analysis revealed that the most common image displayed was the usefulness of science which mainly presents as science an unproblematic and ready-made body of knowledge. It was, however, not possible to conclude why some aspects were more frequent than others or why some aspects were less explicit than the staff members would like them to be. It was not possible, in this phase, to explain the underlying assumptions and factors that affect how science is constituted and outlined in exhibitions at Nordic STCs. However, the analysis of the questionnaire as well as the review of previous research presented in the theoretical background in the article, made it possible to pose different assumptions or factors which, hypothetically, could affect how science is constituted in exhibitions.

1. Staff members' ideas about the nature of science affect how science is constituted and outlined in exhibitions
2. Staff members' ideas about visitors' learning affect how science is constituted and outlined in exhibitions
3. Economic interests affect how science is constituted and outlined in exhibitions

This does not mean that these hypotheses cover all possible assumptions and factors which could affect the final result of an exhibition, but they highlight three perspectives of the main research question of this thesis. These hypotheses will be further discussed in the chapter Theoretical framework (Chapter 3).

2.2 Approaching staff members' views of visitors' learning and what scientific aspects to include

As mentioned before, the quantitative approach did not actually describe the staff members' considerations and actions when planning and constructing new exhibitions. Neither did it thoroughly explore the staff members' ideas about visitors' learning when interacting with exhibits. To come close to these matters, as well as to explore the validity of the

hypotheses seemed to demand other methodological approaches. Therefore, a participant observatory study was planned. But what results were expected outcomes from such a study? Were the results of the previous study sufficient as a pre-understanding to be able to analyse this context and discourse? In order to obtain indications about what issues on which to focus when conducting the participant observatory study, it was preceded by an interview study. The aim was to explore the staff members' ideas about visitors' learning as well as to study their considerations when choosing what scientific aspects to include in exhibitions. Patton (2002) describes the purpose of such qualitative interviewing as capturing "how those being interviewed view their world, to capture *their* terminology and judgements, and to capture the complexities of *their* individual perceptions and experiences" (p. 328).

The participants were chosen through purposive sampling (Silverman, 2001; Patton, 2002). The criterion for selection was that the respondents should be responsible for designing and creating new exhibitions at their STC. However, the prospective respondents were spread over a large geographical area and a personal meeting was impossible. Instead telephone interviews were used as a means to approach staff members' considerations about visitors' learning and the scientific content. The interview was semi-structured and consisted of open-ended questions, which means that the respondents did not consider any predetermined phrases or categories. The questions were evaluated in a pilot test before the interviews were conducted. All the respondents were given the same core questions and had opportunities to freely reason without being interrupted. This was done in order to avoid the use of guiding questions and thereby increase the reliability of the study (Kvale, 1997). In all, 17 staff members from 11 different STCs were interviewed for 40 to 60 minutes. All the core questions for the interview are found in the interview guide in Appendix II.

An advantage of using an interview guide, Patton (2002) argues, is that it ensures that the same basic lines of inquiry are pursued with each person. This increases the comprehensiveness of the data and makes the data collection more systematic for each respondent. But Patton (2002) also points to limitations when using interviews to collect data. For example this involves the risk of that the responses are distorted due to personal bias, politics, anxiety or a lack of awareness during the interview. Another weakness can be that it is problematic to study the re-

spondents' views of visitors' learning and their ideas about science, in action when planning exhibitions. Instead they were asked to comment on these issues "on display". However, an aim of this study was to prepare for the following phase of data collection where such limitations could be circumvented. Other methodological considerations concerning this data collection are described in the articles *Staff Members' Ideas About Visitors' Learning at Science and Technology Centres* (Davidsson & Jakobsson, in press) and *Enhancing Visitors' Interest in Science – A Possibility or a Paradox?* (Davidsson, accepted).

2.3 Exploring the effect of economic interests on how science is constituted in exhibitions

The analysis from the interviews revealed that the respondents referred to learning processes differently by distinguishing organised from non-organised learning, theoretical from practical hands-on learning and serious from non-serious learning. According to most of the staff members, these conclude with different learning outcomes. When it comes to how the staff members consider the scientific content of their exhibitions they discuss this issue to a high extent in organisational terms. A major problem does not seem to be in choosing what aspects of science to include, but instead there seems to be a focus on problems related to how to organize the content and solve practical and everyday concerns. Further on, the staff members express an anxiety in displaying non-consensus issues or different models of explanations in science, when arguing that this risks confusing the visitors. Apart from the reported results, the analysis of the interviews also highlighted another issue, which seemed to affect how science is constituted in exhibitions. Without any initiative from the interviewer, some respondents discussed episodes where sponsors had modified, changed or replaced parts of the exhibition content in order to convey a different image of science. To come closer to all these issues from the first and second phase of data collection, the participant observation was carried out. The aim was to explore the first and second hypotheses in action and by this overcome some limitations which arouse when using a questionnaire and interviews. Furthermore, it aimed at investigating the validity of the third hypothesis.

The first step in the third phase of the data collection was to gain access to a milieu where new exhibitions were planned and constructed. Therefore a science and technology centre was contacted and resulted in a personal meeting with the head of the centre. After having discussed the research topics and focus of the study, it was possible to follow the meetings of the development department, where the members discussed and decided about forthcoming exhibitions. This group consisted of four persons where two had educational and professional backgrounds as engineers, one as biologist and one as communicator. The data collection also included a personal conversation with each of the group member, where they discussed the latest exhibitions in which they had played the role of project leader. In all, 16 meetings of the development department were attended during a period of five months and resulted in 40 hours of video or audio recorded data. During these meetings, different exhibitions in different stages were discussed.

However, in the analysis of the data it became evident that these discussions, to a large extent, concerned organisational matters, how to attract visitors and practical possibilities and limitations in relation to exhibits. This means that discussions about what scientific content and what aspects to include or how to present different topics in relation to their views about visitors' learning were almost absent. When it came to discussions about economic aspects and the possible affects on the content of the exhibitions, these were represented to some extent. However, these discussions almost exclusively concerned how to attract visitors through for example happenings or how to attract schools to their STC. These issues were not discussed in relation to what different aspects of science they, as staff members, could choose to display, but instead in relation to how they could advertise or provide teachers with school material. Another economic aspect concerned the cost of developing and using software and new technology in the exhibitions.

But why was the scientific content and visitors' learning not discussed to a greater extent and why were economic effects not discussed more critically? There could be several explanations to this matter such as that these issues are implicitly known to the staff members and there is thus no need to discuss them more explicitly. Another explanation could be that they do not consider these discussions as important or that organisational matters are so immediate and extensive that there is no time left for other discussions. Yet another explanation could be that

these matters actually are discussed, but not in the forums which were the subjects of this study. Since staff members' considerations about what scientific aspects to include, ideas about visitors' learning as well as economic influences have become explicit factors which seem to affect how science is constituted in exhibitions, it was necessary to further scrutinize these issues. Therefore, the last attended meeting was followed up by a focus group interview. The purpose was to create prerequisites to explore and make explicit the staff members' ideas about what factors, actually influence the content and the design of exhibitions. This means that they were given the opportunity to freely reason and discuss. The focus group interview lasted for 1.5 hours and was video recorded. According to Patton (2002), the interactions between the participants in the focus group enhance data quality, as the respondents tend to provide checks and balance on each other, which weeds out false or extreme views. The group members, in addition, influence and inspire each other by responding to ideas during the discussion. The data collection also comprised a personal meeting with one person of the management group which also focused on factors and assumptions which could affect the final content and the design of exhibitions.

The analysis of the focus group interview revealed that the staff members, to a great extent, focused economic concerns and sponsors' interference when planning new exhibitions. For example, the respondents discussed self-censorship where they themselves took sponsors into account when deciding what scientific aspects to include in exhibitions. The staff members' focus on economic concerns and the significance of sponsors' influences on exhibitions, lead to a decision to further explore this factor and resulted in the fourth article. For this analysis all previous data material was also included. This means that the questions about economy in the questionnaire were analysed to obtain a general view of the extent to which sponsors are used, but also whether the staff members experienced interference in the process of planning their latest exhibition. Furthermore, the interviews, observations and the focus group interview were analysed in a two phase analysis. In the first phase, all situations in which the staff members discussed economic issues in relation to the content of the exhibitions were identified. These situations were categorised and described and subsequently, during the second phase, different subcategories emerged. The methodological considerations concerning the focus group interview and analysis are

described in detailed in the article *Economic Interests and Science Exhibitions – A Study of How Sponsors May Affect Exhibition Contents* (Davidsson & Sørensen, submitted).

2.4 Overview of the relations between research question, hypotheses, data material and articles

This overview aims to graphically illustrate the relations between the main research question, the posed hypotheses, the different data collections and the articles. The starting point in this thesis was the main research question which led to the article *Different Images of Science at Nordic Science Centres*. This resulted in three different hypotheses which were explored in three articles. This is illustrated in Figure 1.

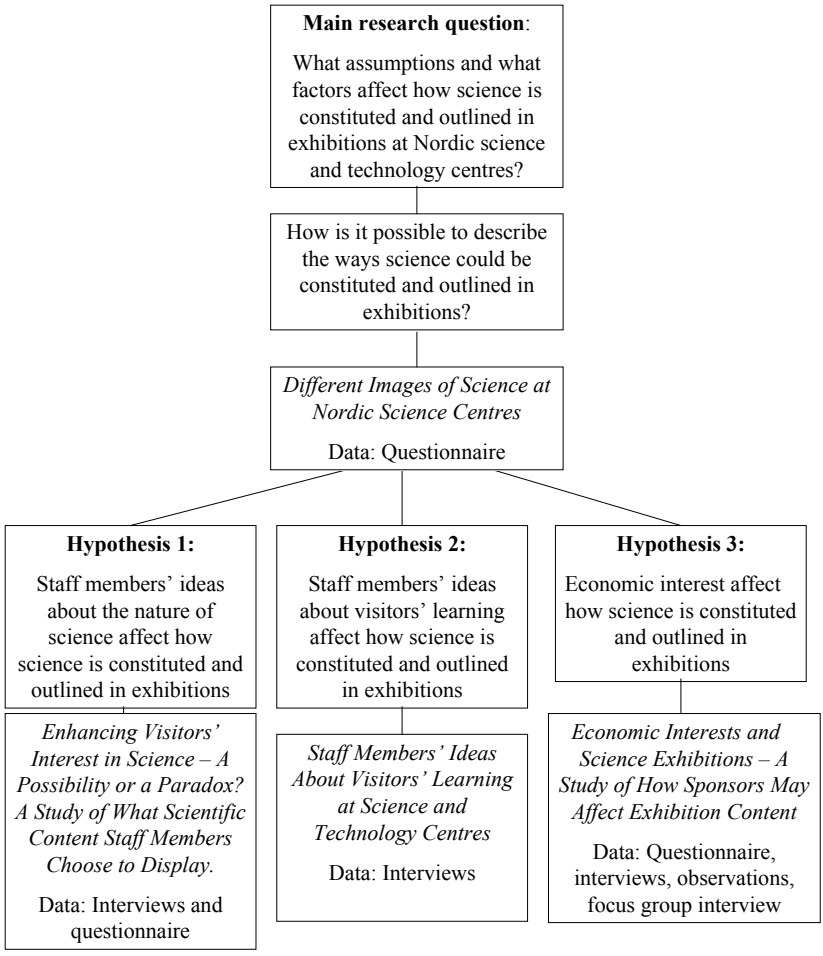

Figure 1. Overview of research question, hypothesis, data collections and articles.

3 THEORETICAL FRAMEWORK

The aim of this chapter is to describe the theoretical framework, which provided a background and a starting point for exploring the research question about the assumptions and about factors that affect how science is constituted in exhibitions. This framework is comprised of four parts, where the first is a review of current research within the field of STCs. Most research within this field concerns visitors and what they do and what they learn when attending exhibitions. The purpose is to highlight and discuss different foci visitor studies could have, but also to discuss whether outcomes from visitor studies are dependent on how science is constituted and outlined in exhibitions. The second part in this framework highlights the discussion within the science education enterprise concerning the role of learning about the nature of science (NOS). The aim is to discuss features of NOS and to explore what consequences an inclusion of NOS aspects in exhibitions could have.

The next part concerns a sociocultural approach to learning and focuses on the concept of mediation. It aims to explore how this perspective on learning may contribute to an increased understanding of visitors' learning through interaction with exhibits. Finally, the fourth part discusses economic prerequisites for STCs and museums. It aims to explore in what ways the financial situation of STCs could affect the content and the design of exhibitions.

3.1 Research within the field of science and technology centres

Research within the field of STCs and other informal environments has traditionally focused on exploring questions about either the visitors or

the exhibits. Rennie (2001) argues that these foci, to a large extent, concern why visitors come to STCs, what they do and what they learn, as well as exhibit appraisals. The data are usually collected from the visitors, including for exhibit appraisal, since the effectiveness of the exhibits is measured in relation to visitors' reactions. In order to clarify the different foci that usually are adopted in STC research, Rennie (2001) provides an overview (Figure 2).

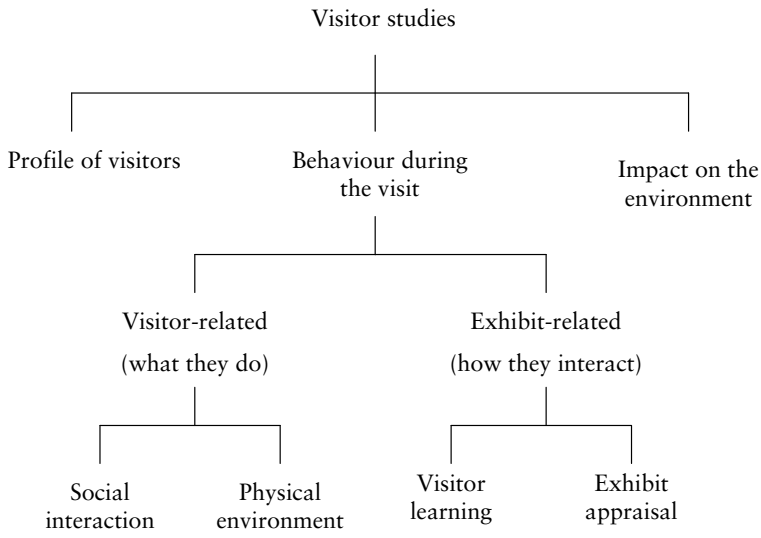

Figure 2. Some foci of research in museums and similar institutions (Rennie, 2001)

The model describes three main foci of visitor studies usually considered, and also implies possible underlying aims. The first focus concerns mainly demographic parameters and data about who the visitors are, which can be used to create and understand different *profiles of the visitors*. The second focus, *behaviour during the visit*, is described as having two main aims. The first is visitor-related and explores issues concerning what the visitors do in terms of social interaction and physical environment. The other aim is exhibit-related and deals with questions about what the visitors learn or how the exhibit appraised. Finally, the third focus, *impact on the environment*, consists of questions about the physical effects of wear and tear on the exhibit and its location.

This overview was a source of inspiration and provided a possible starting point in this section for describing different areas of research concerning visitor studies. As seen in Figure 2, Rennie (2001.) differentiates *visitors' learning* from *social interaction* and subcategorises these aspects under *visitors' behaviour*. But when considering a sociocultural approach to learning, social interaction instead could be referred to as learning through human mediation (e.g. Rogoff, 1995, Kozulin, 2003). Similarly, visitors' learning through interacting with exhibits could count as learning through artefacts (e.g. Kozulin, 1998). According to this approach, this means that visitors' learning at STCs could consist of both visitors' social interactions and their interactions with exhibits. This issue is further discussed in section 3.3.

To be able to understand how visitors' learning can be constituted at STCs according to a sociocultural perspective, it is necessary therefore to suggest a modification of Rennie's model. This would mean that visitors' learning would be in focus both when it comes to exploring visitors' interactions with exhibits or exhibit appraisals and when social interaction is considered. The proposed model is shown in Figure 3.

In this model (Figure 3), it can be seen that *profile of the visitors*, *visitors' learning* and *impact on the environment* are considered as three main foci when conducting visitor studies. The model should be understood as showing that there exists a dialectic relationship between visitor related and exhibit related learning. This means that it is impossible to separate learning through social interaction from learning through exhibit interaction.

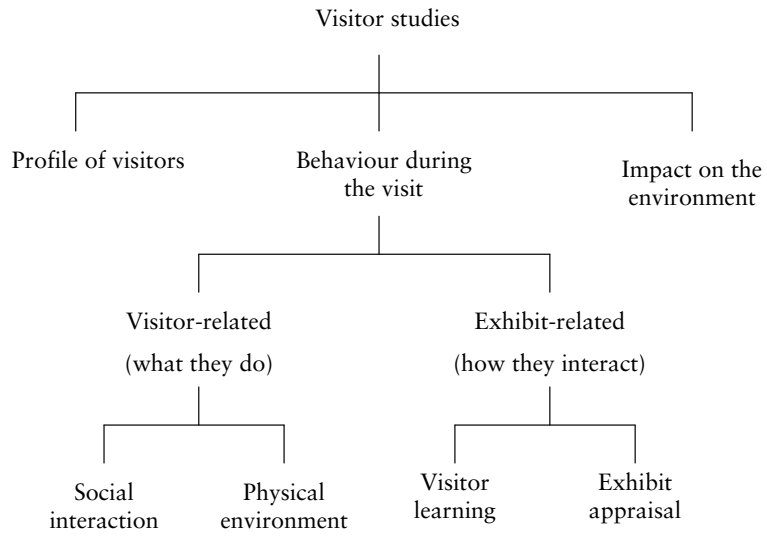

Figure 3. Different foci of visitor studies in the field of STC research according to a sociocultural approach.

This model constituted a starting point for the following discussion whose purpose is to highlight and exemplify research, focusing *profile of the visitors* and *visitors' learning*, within the frame of STCs. The classification is however overlapping, since there are studies which concern visitors' learning in relation to the profile of the visitors. These studies are discussed in the first category. The third category, *impact on the environment,* will not be discussed, since research within this areas is unusual and often only of local interest.

3.1.1 Profile of the visitors

The *profile of the visitors* may include questions about *who* and *why* visitors attend exhibitions. Rennie (2001) argues that many museums usually handle the questions of who attends exhibitions and carry out surveys in order to gain demographic data such as age, residential area, occupation and other background variables of typical visitors. However, some research studies focus on why people attend exhibitions to be able to find out about their agendas and personal motivations for coming.

Falk and Dierking (2000) describe the profile of visitors from people's personal and everyday context. They highlight the issues of a person's motivation for and expectations of a visit as well as the knowledge, interests and beliefs a person brings to the visit. The following discussion emphasises visitors' agendas from the leisure visitors' perspective and from the teachers' perspective in school contexts.

The leisure visitors' agendas

To be able to explore visitors' motives for attending exhibitions, Moussouri (1997) interviewed museum visitors. The results reveal that these motivational agendas could be classified into six main categories. The first category and the most frequent answer was the motive of *education* and is related to the aesthetic, informational or cultural content of the exhibition. The second most frequent reason was *entertainment*. Furthermore, the museum visit was referred to as a *social event* but also a part of a *life cycle*. This means that attending a museum was sometimes seen as important in certain stages of life, such as bringing your grand children to museums. The next category was *place* and signifies when visitors thought of visits as leisure, cultural or recreational destinations associated with a certain place, as for example a tourist visiting a museum during the holiday. Finally, the category of *practical* issues includes factors such as weather and time availability. Moussouri (1997) also described visitors' strategies when attending an exhibition and found that these fall along a continuum from unfocused to focused.

This study was followed up by Falk, Moussouri and Coulson (1998) as they explored the visitors' agendas in relation to their learning outcomes. They compared pre- and post test answers from adult visitors with their agendas of the visits and found that only the categories of education and entertainment were significantly related to positive learning outcomes. In addition they found that the visitors did not consider the aim of entertainment and education as conflicting. On the contrary, the visitors expected to achieve both. Also Leinhardt, Tittle and Knutson (2002) explored visitors' purposes of visiting museums. They asked 18 frequent museum visitors to attend five museums over a period of four to six months and to write a diary account of each visit. From the diaries the authors were able to distinguish three general purposes of the visits. The *floating* purpose comprises enriching the day or just passing time as the informants were open to whatever experience offered. However,

other occasions were, according to the authors, *focused* on what the informant wanted to see or when they wanted to experience something special. The last purpose was called *challenging* as the visitors pressed themselves to be expansive and the diarists seemed to sense that there was more to learn in a general way. The analysis also revealed that these different purposes could be related to age as the younger visitors to a higher extent than the seniors tended to visit museums for floating reasons. The senior visitors instead mainly mentioned focused reasons.

It seems thus to be possible to distinguish different agendas of leisure visitors but also that these agendas tend to be different in relation to the visitors age. But is it possible to find different agendas also when it comes to teachers and their views of museum visits?

The teachers' agendas in school contexts

According to Kisiel (2005), most teachers seem to consider fieldtrips as educational events. He argues that teachers regard museum visits as opportunities were students can gain new knowledge, curriculum related or not, as well as new experiences unlike those gained in the classroom. Furthermore, he investigated elementary teachers' agendas for conducting a fieldtrip and found that the teachers believe it is important that the topic of the fieldtrip connect with the classroom curriculum. The teachers did however seem to have different notions about how the exhibitions were related to the curriculum. But in what ways do the teacher's agendas and actions affect the students' learning outcomes? Lucas (2000) argues that in order to enhance students' learning from fieldtrips there is a need to increase the students' familiarity with the physical setting, to ensure that students have appropriate knowledge about the topics of the exhibition and to provide prior opportunities to practice relevant skills. According to Lucas (2000), these issues require actions of the teachers or of the teachers in cooperation with staff members from the museum prior to the visit.

Also DeWitt and Osborne (2007) emphasise the importance of the teacher's involvement such as conducting pre- and post-activities in relation to a STC visit. But despite several research studies (e.g. Rennie & McClafferty, 1995) that emphasise the significance in pre- and post activities, Tal, Bamberger and Morag (2005) conclude that this is seldom considered by teachers. They investigated the roles and perceptions of Israeli teachers, who visited natural history museums with their classes.

The analysis showed that none of the interviewed teachers acted as an active facilitator during the visit and the teachers had, to a large extent, no idea about the field trip program or rationales. According to the authors, one reason for this may be that the teachers tend to employ companies which plan the museum arrangements. Their results are in line with the study of Griffin and Symington (1997). Through observations and interviews before, during and after a museum visit, they explored what learning purposes, preparations and follow-up teachers did in relation to the visit. Furthermore, they investigated whether the teachers linked the exhibition topics to what they studied in school. The results reveal that only half of the 29 teachers could give a purpose of the visit related to any learning goals. The ultimate goal seemed to be the completion of work sheets. In general was there little preparations and when it did occur, it was mainly organisational. The teachers made little effort to connect the topic of the exhibition to the ones studied in the classroom. Most teachers said they would relate the museum visit to the work in school after the visit, but follow-up activities did not commonly occur. The post-activities mainly concerned collecting and marking the work sheets made by the students. When it comes to whether the teachers linked the classroom topic to the focus of the exhibition, the authors found that this was done to a very low extent.

From these results, it seems that there exists a gap between the research community concerning the teachers' role of enhancing students' learning and how teachers actually approach fieldtrips. In order to address this problem, different frameworks for integrating museum visits into school activities have been developed. One example is the school-museum integrated learning experiences in science (SMILES) developed by Griffin (1998). This model focuses on different guidelines which may increase prerequisites for enhanced learning in relation to museum visits so as to provide conditions for self-directed learning, integrate museum and school learning and facilitate learning strategies. Another framework, developed by DeWitt and Osborne (2007), relies upon the perspectives of cultural historical activity theory, theories of intrinsic motivation and research about conceptual learning. It draws upon four main principles: adopting the perspective of the teacher, providing structure, encouraging joint productive activity and supporting dialogue, literacy and/or research skills. The aim is to provide a resource

to museum educators in order to create prerequisites for teachers to improve learning opportunities in relation to fieldtrips.

3.1.2 Visitors' learning

Social interaction, focus on families

One approach to investigate visitors' learning is to explore the social interaction between the family members as well as between the family members and curators or explainers. The research design for studies with such a focus often concerns analysing family conversations while interacting with exhibits. Allen (2002) argues that analysis of visitors' conversations as a methodology offers a rich description of what the visitors really do and talk about. In her study she focuses on, visitor dialogues with the aim of identifying what she describes as learning talk. Learning talk is characterised as perceptual, conceptual, connecting, strategic or affective talk. The conversations of 49 visiting pairs were recorded and classified into these categories. The results show that over 80% of the total conversation during the visit could be considered as learning talk. The most frequent learning talk was perceptual and conceptual talk. Similar results are provided by Griffin, Meehan and Jay (2003) as they showed that when students move freely in the exhibition, over 80% of their conversations could be classified as learning-related discussions. This means, for example, that they linked to previous experiences or discussed similarities and differences of exhibits. Their learning-relating conversations tended to occur when walking between the exhibits and not necessarily while interacting with the exhibits. In front of the exhibits, the students instead tried to draw attention to things in which they were interested.

But to what extent and in what ways does the content of the exhibitions affect and drive the visitors' conversations? Ash (2002) considered this issue when exploring families' dialogues, in order to describe how they make sense of biological themes and the principle of adaptation. She analysed families' interactions with exhibits and focused on their negotiations of adaptation and discovered that powerful thematic content is the underpinning for meaning-making conversations. This means that the families need something interesting and complex to discuss and the complexity needs to bridge differences in age and expertise. The issue of complex discussions is also highlighted in a study of Crowley and

Jacobs (2002) who explored how different mediating parent talk affects the children's learning. The parents and children were asked to interact with both authentic and replicated fossils and their conversations were recorded and analysed on the basis of different kinds of mediating parent talk. The analysis revealed that more complex discussions or higher levels of parent mediation such as explanations, inferences about scale or connections to previous experience and anatomy, resulted in the young children (4- to 6-year-olds) being able to identify more of the fossils on a post test.

Complexity in dialogues in addition seems to create prerequisites for increased scientific literacy. Ash (2004) continued the previous work of how families create meaning about the principle of adaptation in a museum setting, focusing how conversations of one bilingual family can become a basis for broader scientific literacy. To be able to distinguish dialogues which indicate scientific literacy among the participants, Hurd's (1998) three features of scientific literacy was used. This framework comprises a) distinguishing data from myth and folklore and knowledge from opinions, b) recognizing the ongoing and cumulative nature of science, and the influence of science on society and c) knowledge about data, its processing and that there can be multiple solutions and answers to scientific questions that impact society in many ways. The analysis revealed that the family used many different resources, including prior knowledge, pictures, live and preserved objects, the curator and both Spanish and English in order to distinguish real data from myths. Furthermore, they were able to gradually and cumulatively argue for conservation of corals and thereby recognize the influence of science on society. The family also gradually generalized across multiple cases and by that also fulfilled the third feature of scientific literacy.

The studies of Ash (2002), Ash (2004) and Crowley and Jacobs (2002) discussed family conversations from a starting point where the family members were novices in relation to the actual theme of the exhibition. However, it seems like the character of the conversations shifts when the children have more knowledge about the specific topic displayed in the exhibition. Palmquist and Crowley (2007) investigated how the family learning opportunity is influenced by the children's level of dinosaur expertise when visiting a natural history museum. They describe the children's expert knowledge as islands of expertise which refer to topics in which children happen to become interested and develop

a relatively deep knowledge about, such as for example dinosaurs. The analysis of the family conversations reveals that the parents with novice children more actively engaged them in learning conversations than the parents with expert children. This means that the expert children tend to recite facts and stories but do not interrogate the environment for new pieces of information. This behaviour was supported and reinforced by their parents. In contrast, the parents with novice children acted as responsive learning partners and guided interpretations of different specimens. In families with expert children the parents to a larger extent acted as evaluators or testers. Palmquist and Crowley argue that the expert children encounter a glass ceiling above their island of expertise and museums need to support children and parents to move beyond this and connect their expertise knowledge to other related domains. But when it comes to the parents' knowledge about how to support their children's learning, it is clear that this is not an obvious matter. Callanan, Lipson and Stampf-Soennichsen (2002) investigated the parents' talk in order to describe how children might learn about symbolic relationships and representational objects. Their results reveal that parents tended to discuss science with their children in ways that focused on particular events rather than abstract principles. They were thus not likely to teach children about abstract concepts such as dual representations. Instead they talked to them as they actually did understand symbolic objects for what they are such as for example that the globe is a representation of the Earth.

Their results also seem valid when it comes to staff members' and explainers' ability to support learning. Rosenthal and Blankman-Hetrick (2002) argue that the idea that explainers naturally possess teaching abilities or abilities to engage visitors is false. In their study they explored the role of the explainers for family learning in a living history museum. This specific kind of museum involves the explainers to act as historical characters who converse with the visitors in the exhibition. Their study sought to describe circumstances in which family learning is most likely to take place. The results suggest that the nature of family interaction with explainers had the greatest impact on learning. This means that if both the whole family and the explainer became involved in a reflexive dialogue, it turned out to be easier for the families to talk among themselves. If the explainer turned to the children directly, the parents also became involved. However if the explainer only paid atten-

tion to the parents the children were likely unengaged. From these results, the authors argue that explainers must have adequate training in order to stimulate visitors' discovery.

Social interaction, focus on schools

As in the previous section, research about social interactions at STCs in school contexts highlights interactions between visitors and between visitors and curators or explainers. The research questions usually concern guided tours and the social interaction between curators or educators and students as well as students' peer interactions. One example of investigations about guided tours is the study of Cox-Petersen, Marsh, Kisiel, and Melber (2003). They explored the ways in which the content and the pedagogy of docent-led guided school tours correspond with conclusions from research within science education. Through observations of guided tours but also through interviews with accompanying teachers, students and staff, the authors found that the guided tours were considered to be a satisfactory experience for students and teachers. But according to the analysis, the outlining of the tour was found to be inconsistent in relation to research conclusions within science education. This means, according to the authors, that the tours above all were fast-paced and only focused on covering displays and providing information. In addition, most information was fact-based and did not focus on overarching ideas or concepts within the exhibit. The interviews with students and teachers revealed that the tour content was to a low extent related to the students' prior knowledge or their interests. Furthermore, the content was presented didactically and authoritatively with limited amount of dialogues between docent, students and teachers.

The results of this study are well in line with the results of Tal and Morag (2007). They also explored school visits and guided tours in order to investigate the characteristics of the guided visits and to study how the museum content was communicated to students. The data consists of observations of 42 guided tours at four different natural history museums. The analysis showed that the visits were guide-centred and lecture-oriented activities. Furthermore, they analysed the scientific vocabulary and questions and found that a) a large number of scientific terms were used by the guides, b) these were poorly explained or discussed, c) questions were the most common way to communicate with the students, d) most questions required only simple answers and e)

many questions were posed without intentions of receiving an answer. The authors argue that from these results, the students have little opportunity to engage with objects and peers.

However the criticism that guided tours tend to be lecture-oriented and non-dialogic is nuanced in the study of Tran (2006). She describes instruction undertaken in a museum setting by observing the explainers. The results reveal that the explainers adapted their pre-planned lessons to the needs, interests and abilities of their classes and this could be done by using segmented lesson design. This design means that different parts of the lessons were divided into talk, demonstration or activity and allowed the explainer to adjust and adapt the lesson regarding the mutual quantity of these segments as well as, to some extent, the content while teaching. But the results also revealed that the explainers to a large extent communicated with the students through the pattern of the triadic dialogue (Lemke, 1990), initiate-response-evaluation. According to the author, this is considered as a failure in as an attempt to let students articulate their own thoughts and ideas. In this way, the results of this study support the results of Tal and Morag (2007) since there tend to be a lack of dialogues between visitors and museum educators. Despite the more nuanced results from the study of Tran (2006), there seems to exist some criticism about how museum educators handle and confront student groups in guiding tours and teaching situations.

When it comes to students' peer interactions, it seems that this research area has been studied to a lesser extent. This means that there are fewer studies concerning students' dialogues when interacting with exhibits than about families' dialogues. One example, however, is the study by Tunnicliffe (2000) whose aim was to compare the conversational content of families with those of school groups while attending an exhibition at a national history museum. The study focused on the conversations which took place when the visitors interacted with animatronic dinosaurs. The analysis of students' and families' dialogues revealed that both groups, to a large extent, focused on the same conversational content such as body features. However, families made more management/social comments in their groups than the school groups do. Another example of exploring students' learning through peer conversations is the study by Rahm (2004). The study highlighted peer conversations as well as student-curator conversations. The starting point of the analysis was that local meaning-making is illustrated through different

modalities such as doing, talking and manipulating the exhibits. The analysis revealed that the visitors used three different lines of sense-making such as understanding the meaning of the exhibit, understanding the illustrated scientific phenomena, and youths' own sense-making of the actual phenomena. These different lines or discourses constitute, according to Rahm (2004) learning in science museums.

Visitors' learning in relation to exhibits

Visitors' learning in relation to exhibits mainly concerns the visitors' interaction with the exhibits and generally describes artefact-mediated learning. Rennie (2001) argues that much research within this area relates to exhibit appraisal. One example is the study by Quistgaard (2006) who explored upper secondary students' preferences and engagements in different exhibits. She found that both girls and boys tended to value self-oriented exhibits as more engaging. This means that the students preferred exhibits where it was possible to test and measure their physical and mental abilities. Also Fors (2006) explored teenagers' preferences when visiting an exhibition. The results showed that the informants preferred exhibits in which they had the authority to interpret and contribute to the meaning-making processes. Furthermore, they wanted to use exhibits which negotiated their development of social identity.

Other studies seek to compare different kinds of informal settings in relation to visitors' learning. One example is the study of Rennie and Williams (2006), in which they compared the impact on visitors' ideas about scientific knowledge, depending on whether a visitor attended an exhibition at a STC, a natural history museum or a public lecture. The analysis of pre- and post tests suggests that the visitors, independent of venue, became more positive about the value of science and the work of scientists after their visits. However, the results further show that visitors, independent of venue, tended to become less scientific when considering the nature of scientific knowledge. From these results, the authors argue that the places are relatively passive learning environments. According to the authors, this means that the exhibit design tends to draw the visitors' attention towards consensus explanations of phenomena and concepts.

But what different features of exhibits are significant in relation to visitors learning? Lindemann-Matthies and Kamer (2006) explored the

effect of a touch table on visitors' learning at a zoo comprising 600 visitors. The touch table concerned information about the bearded vulture. A control group did not have access to the touch tables, but could only use traditional resources such as posters and labels. The researchers found that the visitors in general wanted to be informed about indigenous species and used the educational material which was offered. However, the control group reported less frequently that they had learnt new things than the test group who used the touch tables. The test group knew more about the biology, ecology and conservation of bearded vultures both immediately after the visit and two months later. In addition, they were more satisfied with the visitor information than the control group. This study could however not explain the underlying causes of these differences.

Another feature explored, is the effect of visitors' learning when using audio guided tours. Novey and Hall (2007) compared visitors' knowledge development through pre- and post tests of 123 audio users and 131 non users, when attending a cave in a national park. The data also consisted of observations at seven sites within the cave, documenting sign reading, time spent on each site, time spent listening to the audio and within group conversations. From the analysis it was clear that the audio users listened extensively to the narration. Across all observational sites audio users spent more total time focusing on the content. The audio tour was however not superior in conveying information, as they found no differences in the number of correct answers at the knowledge quiz in the post test. Furthermore, the analysis revealed that the visitors, both audio users and non-users, spent considerable time reading signs in the cave. Finally, the audio tours did not seem to impede social interactions. The impact of using audio guides to enhance learning seems to be inconsistent with the study of Heard, Divall and Johnson (2000). They found a gender impact as the audio guides greatly facilitated the girls' activities and improved their results on the post test compared to those girls who did not use the audio guide. A possible explanation to these results is that the girls who used the audio guide actually used the proposed instructions when interacting with the exhibits. Borun (2002) highlights another focus of the impact on visitors' learning in relation to exhibit design, when comparing the effect of providing labels close to the exhibits and unlabeled exhibits. The results revealed

that hands-on exhibits with careful labelling clearly enhance visitors' understanding.

3.1.3 Visitor studies and science exhibitions

This review took its starting point as the perspective of the visitors, in who they are, why they visit STCs or museums and in the learning outcomes when they interact with exhibits, peers, curators or teachers. However, the studies reviewed seldom discuss if any relationship exists between the results of the study and the way science was constituted and outlined in that particular exhibition.

There are, though, indications that the way science is constituted, has an impact on visitors' views of the nature of scientific knowledge, as visitors' tend to adopt a less scientific view after they have attended an exhibition (e.g. Rennie & Williams, 2002; 2006). This means, for example, that the respondents were more likely to think uncritically about science after their visit to the centre. One explanation for this could be found in studies where museum staff, during guided tours, tended to exclude aspects of the nature of science (e.g. Cox-Petersen et al, 2003; Tal & Morag, 2007). Another explanation could be the studies which imply that there is a lack of dialogues in many museum activities such as guided tours and in other learning situations (e.g. Rosenthal & Blankman-Hetrick, 2002). This means that important characteristics of scientific activities, such as argumentation, posing hypothesises and drawing conclusions risk being overlooked as a significant learning aims. From this perspective, the criticism of displaying too narrow a view of science (e.g. Pedretti, 2002; Davidsson & Jakobsson, 2007) seems valid in exhibition settings.

There are, however, studies indicating that exhibitions have the potential of enhancing visitors' dialogues and learning and engaging visitors in learning talk (Allen, 2002). There are also indications that an increased complexity of an exhibits' thematic content may carry the potential of overarching age and expertise and can thereby involve visitors, independent of background, in engaging conversations (Ash, 2002). From this reasoning two pictures emerge, which can constitute two extremes in a continuum from where it is possible to describe different exhibitions. On the one hand there are exhibits, strictly representing consensus explanations of phenomena and concepts. On the other hand

there are exhibits, which provide a complex thematic content (Ash, 2002), representing a broader view of science and include different aspects of the nature of science. But what is actually meant by the concept of the nature of science? What are its characteristics? And what consequences could an inclusion of the nature of science in exhibitions bring?

3.2 The nature of science and science exhibitions

One main hypothesis in this thesis is that STC staff members' ideas about the nature of science affect how science is constituted and outlined in exhibitions. This means that their understanding of the nature of science (NOS) affect what aspects of science they choose to display. Aspects of science refer to different foci an exhibition could have, such as science history, gender issues, scientific methods or controversial issues and is further discussed in the article *Different Images of Science at Nordic Science Centres* (Davidsson & Jakobsson, 2007). From the results of this study, it was evident that the most common image of science displayed at Nordic STCs focused on the *usefulness of science*, which refers to the good things we humans have accomplished through science and technology. The image focuses on the aspects science in society, science in a technical perspective, how modern science is generated and scientific facts. This image represents a view of science which is in line with the critique of displaying a too narrow view of what science may be (e.g. Kostner, 1999, Pedretti, 2002). To circumvent this unproblematic image of science, Arnold (1996) suggests that exhibitions need to consider science in a context where social and cultural dynamics reveal the processes of science. Also Pedretti (2004) promotes a challenge to this view of science in exhibitions and argues for an inclusion of NOS aspects.

But what is actually meant by including the NOS in exhibitions and why is it important to display aspects of NOS? The aim of this section is not to elaborate philosophically on the concept of the nature of science but instead to focus on main features of the significance of the NOS, usually considered in the literature and why these aspects could be important contributions in science exhibitions.

3.2.1 Features of the nature of science

McComas, Clough and Almazroa (2000) describe the nature of science as an arena, that blends aspects from social studies, such as the history, sociology and philosophy of science, but which also consider research from the cognitive sciences such as psychology. This arena forms a description of what science is, how it works and how scientists operate but also of how society reacts upon and directs science and scientific endeavors. But Khishfe and Lederman (2006) argue that there is no agreement among philosophers, historians and sociologists of science about a strict definition of the NOS. They conclude however, that several recurring aspects are described in the literature implicating the existence of some agreement to include them in the concept of NOS. These aspects are that scientific knowledge is:

1. socially and culturally embedded,
2. partly subjective (influenced by for example the scientists' backgrounds),
3. partly a product of human imagination and creativity,
4. tentative and
5. empirically based (based on or derived from observations of the natural world)

(Khishfe & Lederman, 2006).

Lederman (2007) further adds the aspects of the distinction between observations and inferences and the functions of and relationships between scientific theories and laws. These aspects thus describe characteristics of scientific activity and the epistemology of science. Lederman (2007) argues that the NOS is often conflated with scientific processes and scientific inquiry. However, these scientific aspects overlap, scientific processes refer to collecting and analysing data and drawing conclusions from individual processes. Scientific inquiry, on the other hand, refers to various scientific processes used in cyclical ways. The concept of NOS is thus used to describe intersected issues of the philosophy, sociology and history of science and McComas, Clough and Almazroa (2000) claim that NOS issues are a fundamental domain of science educators used to portray science to learners. But in what ways is it possible to approach issues of the NOS in teaching and learning situations and what implications do they bring to science exhibitions? Are NOS issues

automatically adopted when learners study science? Or is there a need for making these aspects explicit in learning situations as well as in exhibitions?

Khishfe and Abd-El-Khalick (2002) studied how two groups of sixth-grade students developed their understanding of NOS issues using, on the one hand an explicit, reflective and inquiry teaching approach and on the other an implicit and inquiry oriented instructional approach. Both groups were engaged in the same inquiry activities, but in addition the first group participated in discussions which focused on the tentative, inferential, imaginative and creative aspects of scientific knowledge. Through questionnaires and interviews, it was clear that the implicit group did not change their views of NOS issues during the science course whereas the explicit group, to a large extent, had changed their views of one or more of the NOS aspects. A question related to this study could be what significance for the results did the education actually has, as the implicit group did not have as a learning goal to learn about aspects of the NOS and therefore did not focus on it. However, it still has implications for the importance of making these aspects explicit when portraying science to learners. But it seems like making the NOS explicit in learning situations also requires certain prerequisites. Schwartz and Lederman (2002) highlight the importance of the teachers' scientific knowledge as they studied how two teachers' different levels of subject matter expertise affected their learning and teaching of the NOS. The researchers followed the beginning teachers throughout their first year of teaching and found that the teacher with more extensive subject matter knowledge also held a more well-developed understanding of the NOS. In addition, this teacher also better succeeded in addressing NOS issues when teaching, regardless of science topic.

One possible explanation to these results could be that the teacher, who had more extensive scientific knowledge, also was able to use scientific language more appropriately. Zeidler and Lederman (1989) studied teacher-student interactions and found that the students' views of science differed depending on how the teachers used the language of science. According to the authors, the results indicated that if the teachers tended to only use everyday language, the students were more likely to adopt a relativistic view of science. However this study does not sort out or discuss the significance of how different discourses and different uses of languages influence students' development of scientific or eve-

ryday knowledge. But in what ways is then the use of scientific language in learning situations related to the concept of NOS?

3.2.2 Scientific language and the nature of science

From a sociocultural perspective, natural sciences consist of a body of knowledge composed of, for example, concepts, theories, hypotheses and consensus explanations, as well as a specific and well-defined language. The use of this language is, according to Lemke (1990), crucial in learning situations. He even argues that learning science is to learn to talk science. This involves, for example, learning the conceptual language in reading and writing, in problem solving and reasoning and in practical laboratory work. In a sociocultural approach it is also evident that language is closely related to thinking and is described by, for example, Wertsch (1998) as an irreducible tension between agent (learner) and means (artefacts or collaboration with others) and will be discussed later. The aim of this short discussion is however to examine how scientific language also may portray the NOS.

The characteristics of scientific language can, according to Lemke (1990), be described by the choice of words, metaphors and by its avoidance of many stylistic devices, commonly used in other kinds of languages or discourses. Lemke describes scientific language as being as verbally explicit and universal as possible, avoiding everyday forms of language and using technical terms instead of colloquial synonyms. Furthermore, he argues that scientific language avoids personification, metaphoric language and narratives, the use of casual forms of explanations and it does not refer to individual human beings and their actions. Sutton (1998) stresses the last aspect of Lemke, how voices of humans, involved in scientific activities, gradually fade when scientific endeavours become consensus. This is evident, he argues, in different scientific texts where personification is present in journals, fading in research reviews and reaches human detachment in textbooks. This implies, according to Sutton (1998), that statements of scientific facts such as “atoms are made of protons, neutrons and electrons” risk being considered as something that “was found” rather than suggested or constructed by humans. Does this mean that there also is a risk that aspects of NOS become implicit when using a scientific language?

When compared to the previous presented features of NOS, there seems to be a risk that the norms of the scientific language exclude aspects such as that science is partly a product of human imagination and creativity or that science is socially and culturally embedded. The norms of the scientific language are, according to Lemke (1990), in addition, a *recipe for dull, alienating language* (p.134), which may serve as a barrier between humans and scientific knowledge. Also Abd-el-Khalick (2003) discusses this problem and argues that if science is described only as rational, unproblematic, value-free and procedural, this could lead to that citizens do not attend to science and scientific knowledge, since it does not belong in a "messy", irrational and problematic world. This is supported by Sadler (2004) as he reveals in a review about informal reasoning regarding socio-scientific issues, that students tend to exclude scientific knowledge from their personal knowledge. However, the author does not discuss whether the students actually exclude scientific knowledge or if they talk about scientific phenomena in an everyday language. Another explanation to this could be found in a study of Brown (2006) in which he concludes that students experienced a difficulty in appropriating scientific discourse. The students perceived science as a unique and intense discourse for communication, but also that it contained double meanings and that there was a distinction between verbal and written forms of communication. But in what ways can this discussion about features of the NOS and the importance of language be of relevance in science exhibitions? And in what ways can NOS aspects be used in order to display issues about science and society?

3.2.3 Socio-scientific issues and the nature of science

Within science education, the NOS is often viewed as a means to enhance students' interest in science, due to its potential of bridging the gap between science and society (Rudolph, 2003). Questions which concern science and society are often referred to as socio-scientific issues. But in what ways are the NOS and socio-scientific issues interrelated? Abd-el-Khalick (2003) argues that socio-scientific issues differ from the sort of "end-of-chapter-problems" that usually are addressed in science classrooms. The latter problems are characterized as fully defined, unproblematic and driven by available and focused disciplinary

knowledge and when using a procedure, the right (or wrong) answers come up. Socio-scientific issues are, on the contrary, ill defined, value-laden, and multidisciplinary and invoke among others, aesthetic, ecological, moral, cultural and religious values as well as scientific concepts and theories. Socio-scientific issues do not claim that science and society represent independent entities but, as Sadler (2004) argues, all aspects of science are impossible to separate from the society in which it arises. Ratcliffe and Grace (2003) refer to socio-scientific issues similarly and describe these questions as issues deriving from today's frontiers of scientific knowledge that deal with incomplete information because of conflicting scientific evidence and which address local and global dimensions with political and societal frameworks. From this description, socio-scientific issues could be seen as interrelated to certain NOS aspects such as science being culturally and socially embedded or that science is partly a product of human imagination and creativity. Could socio-scientific issues be used as a means to discuss and explicate NOS aspects in science education?

In order to address socio-scientific issues in learning situations, many scholars advocate using decision-making processes where learners are asked to actively participate and take positions in different societal dilemmas. In addition, these dilemmas include explicating NOS. For example Kolsø (2001) proposes a framework for analyzing the science dimension of controversial socio-scientific issues. This framework involves different topics such as the role of consensus in science, science as one of several societal domains, demands for underpinning evidence and scrutinizing science-related knowledge claims. The aim of the framework is to provide a tool, which broadens the learners' knowledge about controversial socio-scientific issues and to explicate NOS aspects, in order to make informed decisions as citizens. But what conclusions are possible to draw concerning NOS in science exhibitions?

3.2.4 Science exhibitions and the nature of science

The previous review and discussion about the NOS mainly concerned science education and science learning in formal learning environments. However, it seems that this discussion may also be relevant in informal settings, since making clear aspects of the NOS could be considered as a crucial component in order to engage people in science learning. For ex-

ample, Dhingra (2003) explored how students understand the nature of science from different television program genres. The students viewed magazines and documentary programs which presented science as a set of facts with a high degree of certainty. They also viewed the news and programs from the drama genre, which presented science with some uncertainty involved in the interpretations of the results. The results of Dhingra's study showed that the students had no questions and comments after viewing the documentary programs but, after having viewed the drama programs (episodes from the X-Files) the students posed both questions and comments.

When it comes to science exhibitions, several studies have indicated that the scientific content tends to reflect the one of documentary programs from Dhingra's study (e.g. Davidsson and Jakobsson, 2007; Davidsson, submitted; Pedretti, 2002). For example, Rennie and Williams (2002) studied visitors' ideas about the NOS and found that they, after a visit to a STC, held more limited views of the NOS than before their visit. After the visit they were more likely to think that scientific explanations are definite and that science has answers to all problems. Also Bradburne (1998) criticises science exhibitions for focusing almost exclusively on principles and phenomena rather than on processes, to misrepresent the nature of scientific activity and display science out of context. He presents a pessimistic view when arguing that, as a consequence of an unwillingness to change, there is a risk that visitor numbers will decrease.

There is, however, an ongoing debate about scientific content and what scientific aspects to display in exhibitions. Many scholars argue for displaying a broader view of science and including aspects of NOS (e. g. Pedretti, Macdonald, Gitari & McLaughlin, 2001; Arnold, 1996), in order to reach the goals of STCs of enhanced interest in science and an increased scientific literacy among visitors. For example, Pedretti (2004) discusses the scientific content of exhibitions and promotes an issues-based approach as a way to address NOS aspects and socio-scientific issues. In her study, the visitors encountered an issues-based exhibition called the Mine Games, in which they were asked to decide on whether a mine should be built in a town. The visitors were confronted with aspects such as job opportunities, environmental considerations and other dimensions related to this dilemma. The results of the study revealed that the issues-based exhibition provided different learning experiences

for visitors such as promoting reflexivity, evoking the visitors' emotions and stimulating visitors' dialogues and debate. Bradburne (1998) stresses the importance of changing the characteristics of exhibitions and suggests some possible strategies. He mentions that new learning institutions must emphasise the acquisition of new skills, not just information, and should enhance creativity, collaboration and the skill of finding, using and appropriating that new information. Another crucial change is to turn the visitors into users. This means that informal institutions must not rely on casual visitors, but instead provide a range of services which satisfy different interests and expectations.

The starting point for the discussion in this section was the hypothesis that staff members' ideas about science affect how science is constituted in exhibitions. As seen, a broad view of science includes displaying different features of the NOS and could for example be achieved by presenting socio-scientific issues where NOS aspects are explicit and in focus. Furthermore, several researchers stress the importance of learning scientific language and argumentation when studying science, in order to understand the nature of science (e.g. Osborne, 2002; Lemke, 2003). But the relation between language and learning seems to increasingly be considered in the field of STCs. For example, one crucial feature of a study by Pedretti (2004) was to provide prerequisites to stimulate visitors' dialogues as a way of increasing the quality of learning situations at STCs. Also in other studies there is an enhanced focus on learning conversations in exhibitions (e.g. Allen, 2002; Ash, 2002, Crowley & Jacobs, 2002).

But how do staff members at STCs refer to the actual exhibition as a tool for learning and how do they consider visitors' learning when interacting with exhibits?

3.3 Learning and informal settings

A second hypothesis in this thesis is that staff members' ideas about visitors' learning affect how science is constituted and outlined in exhibitions. This means that their approaches to learning could affect their decisions about what aspects of science to display. The results of the second study in this thesis (Davidsson & Jakobsson, in press) revealed that the staff members, when discussing visitors' learning, to a high extent referred to their own personal and professional experiences. More-

over, a majority of the respondents state that they do not use any scientific knowledge about learning when planning and constructing exhibitions. But what scientific approach is possible to use when discussing learning and informal settings?

In science exhibitions, visitors will encounter different artefacts or cultural products which aim to describe, for example, a certain concept or phenomenon, to display scientific processes or to emphasise how the scientific community has reached consensus concerning a certain issue. A central idea about an exhibition is that it will influence the visitors and that exhibits may mediate new thoughts while interacting. The concept of mediation is also central in a sociocultural perspective on learning, where interacting with cultural tools and signs are crucial for learning. The purpose of this section is therefore to discuss the sociocultural approach and to focus on the concept of mediation. The aim is also to explore in what ways this approach could be used in order to increase our understanding of visitors' learning when interacting with exhibits.

3.3.1 A sociocultural perspective on learning

Within a sociocultural perspective on learning, research seeks to explore issues such as in what ways people acquire knowledge and experiences or how people learn to use this knowledge in different contexts. These issues imply that the focus is not on the individuals and their capacities, but as Säljö (2005) argues, a sociocultural perspective instead centres the interactions between individuals, society and resources such as technical devices put at their disposal in their society. Cole (2003) emphasizes this interaction by claiming that the main assumption in a sociocultural perspective is that "the structure and development of human psychological processes emerge through culturally mediated, historically developing, practical activity" (p. 108). By culturally mediated, Cole refers to mediation through artefacts or cultural products which will be a focus of this section. He claims that the initial premise of a sociocultural approach is that a change in human psychological processes emerges simultaneously as she interacts with an artefact. This change may lead to an understanding of the artefact, how the artefact may be used and may mediate new thoughts, in which she may manage and develop her interactions with her environment. Also Wertsch (1998) describes this dia-

lectic relationship as an irreducible tension between agent and mediational means and will be discussed further on.

In addition to using artefacts, Cole (2003) mentions humans' rediscovery of historically created artefacts. This process is referred to as enculturation, where humans become cultural beings. The cultural artefacts are seen as the medium of human development. As the third basic assumption in a sociocultural perspective on learning, Cole refers to practical activity. This notion originates from the reasoning of Karl Marx and states that through practical activity is it possible to study and analyse human psychological processes. Practical activity and the historical accumulation of artefacts implicate a social origin of human thinking processes.

The purpose of this section is to focus on the first, basic premise in a sociocultural perspective - mediation. The aim is further to discuss mediation in relation to exhibitions at STCs. This involves discussing different factors, which could affect and facilitate visitors' appropriation of artefacts.

3.3.2 Mediation through artefacts

It is difficult to find consensus, within a sociocultural perspective, about the use of different concepts when referring to resources that are accessible to us as learners. This means that there exist several concepts, which aim to describe these resources and although similar, they have slightly different notions. Accessible resources may for example be described as mediational means, artefacts, tools, cultural tools, symbolic tools, psychological tools or agents of mediators. Mediational means, which is used by Wertsch (1991, 1998), is a concept of wide notion as it includes all resources put at our disposal. Artefacts which is used by Cole (2003), refers to resources or aspects of the physical world and exclude human mediators. Also Kozulin (2003) distinguishes symbolic mediation from human mediation. This distinction originates from Vygotskij's (1978) notion that "every function in the child's cultural development appears twice; first, on the social level, and later on the individual level, first between people and then inside the child" (p. 57). When referring to available resources, mediational means according to the definition of Wertsch (1991, 1998) and artefacts according to Cole's (2003) definition will be used. Kozulin's (1998, 2003) concept of psy-

chological tools will be referred to as mediational means. However the difference between these two notions will be discussed.

Research about human mediation often involves different forms of mediation, as for example Rogoff's (1995) categories of apprenticeship, guided participation and appropriation, as well as different techniques of mediation. This is exemplified in the study of Bliss, Askew and Macrae (1996) where approval, encouragement, structuration and organization of students' work are related to different types of mediation. Also Mortimer and Scott (2003) focus on the technique of human mediation in school science, as they have developed a framework for analysing the talk in science classrooms. Their analysing framework consists of the five aspects teaching purposes, content, communicative approach, patterns of discourse and teacher interventions. The aim of this section is however not to discuss research about human mediation but as mentioned, focus on mediation through artefacts.

The essence in studying humans and any mediational means, Wertsch (1998) argues, is to examine their interaction or put in another way; to study the irreducible tension between agent and mediational means. This means that if we want to understand learning, it is crucial to understand how the learner interacts with accessible artefacts, but also to understand how these artefacts influence and impact her thoughts. These ideas have their origin in the work of Leontiev (1978) who considered the mediational means as a relationship between the acting human (the subject) and the environment (the object). Leontiev illustrated this relationship through a triangle, where the base line, representing natural, unmediated action connects the subject and the object.

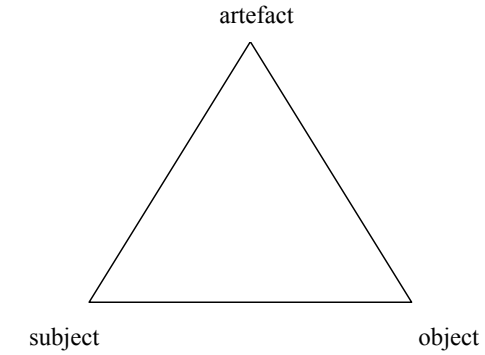

Figure 4. Leontiev (1978) illustrates the relation between a human and her environment as mediated and unmediated action.

Unmediated action refers to processes such as perception, will, memory or attention. The top of the triangle represents mediational means and the connection between the subject and the object via the mediational means represents the mediated action. The triangle thereby simultaneously connects the subject and the object directly and indirectly (Figure 4). However, Cole (2003) points to the risk of interpreting the triangle as when a thought is mediated, it "runs" the path from the subject, through the top and to the object. The emergence of mediated action does not mean replacement of the natural, but rather by including artefacts into the activity, it creates a new structural relation where the natural, unmediated and the cultural, mediated action operate synergistically. This means, according to Cole (2003), that people include auxiliary resources into their actions, in order to appropriate their surroundings to their own goals, which give rise to this triadic relationship of subject-artefact-object.

From this reasoning follows that the subject, or the agent with difficulty may be considered in isolation and as solely responsible for action. Wertsch, Tulviste and Hagstrom (1993) instead describe the agent as agent-operating-with-mediational-means. Agency is thereby understood as extending beyond the individual or as Wertsch (1991) describes it "the mind goes beyond the skin" (p. 33). Correspondingly, this reasoning may be applied to mediational means and artefacts, as all artefacts are produced and designed for a specific purpose. Säljö (2005) argues that when an artefact was constructed, the material was transformed

from one state to another by integrating human knowledge and experiences into the object. Purposely, the artefact was given characteristics such as making a knife sharp or insulating a thermos in order to keep the coffee warm. According to Säljö (2005), the producer of the artefact needs to have extensive knowledge of the construction process and how to enhance the quality of the tool. The users on the other hand, do probably not have that knowledge, but may take advantage of this when using the artefact and thereby sharing collective experiences.

But what characteristics may be addressed to different mediational means? Wertsch (1991, 1998) claims that materiality is a property of any mediational means. Although it is likely to believe that this has to do with physical objects, he also includes both written and spoken language into this notion. The feature of materiality has implications for our understanding of how internal processes emerge and operate when interacting with mediational means. Cole (2003) also stresses the dual material-conceptual nature when using the concept of artefact and defines it as "an aspect of the material world that has been modified over the history of its incorporation into goal-directed human action" (p.117). An artefact, Cole (2003) argues, is both ideal and material. It is ideal or conceptual as no word exists apart from the material form, which means that the form of an artefact extends beyond the mere physical.

Wartofsky (1979) made a distinction between different artefacts, described their characters and labelled them primary, secondary and tertiary artefacts. Primary artefacts are tools such as needles, hammers and axes, but also technical devises or other things that often lead the agent to act in some specific ways. Säljö (2005) refers to these kinds of artefacts as a way of extending our human body and that they thereby facilitate our way of performing activities. Cole (2003) describes primary artefacts as often corresponding closely with the concept of artefact as matter, transformed by prior human activity.

By secondary artefacts, Wartofsky (1979) refers to representations of primary artefacts, but also modes of actions when using primary artefacts. Säljö (2005) exemplifies secondary artefacts by mentioning instructions such as recipes, but also diagrams or other representational systems. They are purposely created to govern our actions and are reflexive in relation to our use of primary artefacts. Wartofsky (1979) also includes values and beliefs in secondary artefacts. His third category of artefacts is the tertiary, which refers to imaginary worlds. These worlds

are relatively autonomous in that they comprise their own rules and norms, which do not necessarily appear directly practical. Säljö (2005) describes the tertiary artefacts as kinds of extensions of secondary artefacts and their practices. They deal with issues such as to arrange, understand and analyse the world, which may be done through art or scientific reasoning. Tertiary artefacts are important in relation to the development of primary artefacts, but may have a hypothetical relation to them. From a knowledge development point of view, Säljö argues that the secondary and tertiary artefacts are central as they build upon and develop representational systems and mediate information about the surrounding through different cultural tools, such as diagrams, texts, pictures or models. These cultural tools contribute to organizing our experiences.

Yet another way to categorize different available resources in our cultural milieu is provided by Kozulin (1998) as he distinguishes psychological tools from material tools. Psychological tools are, like material tools, artificial formations that are by their nature social. In their external form, Kozulin argues, these tools are represented as symbolic artefacts such as signs, symbols, language, formulas and graphic devices. However, as material tools aim to control processes in nature, psychological tools have the purpose of mastering natural behaviour and cognitive processes of the individual. Psychological tools are internally oriented, transforming the inner natural psychological processes into higher mental functioning. This transformation does not mean replacement, but instead the higher mental functions and the lower become intertwined. This development occurs both individually and historically and is also described by Wetsch (1991, 1998) and Cole (2003).

3.3.3 Appropriation of artefacts

Vygotsky (1978, 1981) makes a distinction between lower and higher mental functions and argues that the constructive principle of higher mental functioning exists outside the individual, in interpersonal relations and psychological tools. For example, counting first appears externally with help of different mediational means (e.g. fingers) and disappears as it is internalized. Through the process of internalisation, the lower, natural functions becomes incorporated and superseded in the higher mental functions.

However, Wertsch (1998) questions the use of the word internalization when arguing that most forms of mediated action are never carried out on an internal plane. He clarifies that this is not to say that there do not exist important internal dimensions when carrying out external processes, but argues that the metaphor of internalization is too strong, since it implies something that often does not happen. Hutchins (1995) exemplifies how mediated actions do not need to be internalized through describing how the pilots of an aircraft use complex systems in order to keep the plane at a constant speed. Although the memory process of the aircraft's speed emerges from the activity of the pilots, *the memory of the cockpit* is not made primarily of pilot memory. Wertsch (1998) instead suggests the use of appropriation, which has its origin in the work of Bakhtin (1981). Wertsch (1998) translates and interprets the meaning of the word as "the process of making something one's own" (p. 53).

According to Kozulin (2003), appropriation of mediational means differs from appropriating content learning. He defines content learning as reproduction of empirical realities, as for example to learn that Rome is the capital of Italy. This fact can be learnt both in a formal context and in everyday life. However, using a map as a mediational means could be learnt in a learning activity and would help the learner to find any capital of any country. Kozulin claims that appropriation of mediational means presupposes (a) deliberate, rather than spontaneous character of the learning processes; (b) systematic acquisition of artefacts and (c) emphasis on the generalized nature of artefacts and their applications. Kozulin further argues that a mediational means needs to be appropriated as a generalized instrument, that is, "a psychological tool capable of organizing individual cognitive and learning functions in different contexts and in application to different tasks" (2003, p. 26). This notion is also emphasized by Säljö (2005) when he states that learning is to be able to use the conceptual content of the tools and relate to occurrences and objects in a multi-faced environment in a specific community. However, he emphasizes that it is not the concept as such that is appropriated, since the conceptual knowledge comprises reasoning, considerations and conflicts related to different social practices. Kozulin (1998) further argues that the learner neither appropriates concepts in ready-made forms, nor constructs them independently on the basis of her own experiences. This means that learning must be understood both as a content dependent and situated dependent occurrence.

The process of appropriation is described by Säljö (2000, 2005) as a process of coordination, in which humans interact with different mediational means. This means that we learn to view our environment through different and increasingly complex artefacts and we learn to participate in more differentiated practises. Säljö (2005) illustrates this in a model of increasing coordination between artefacts and user (figure 5).

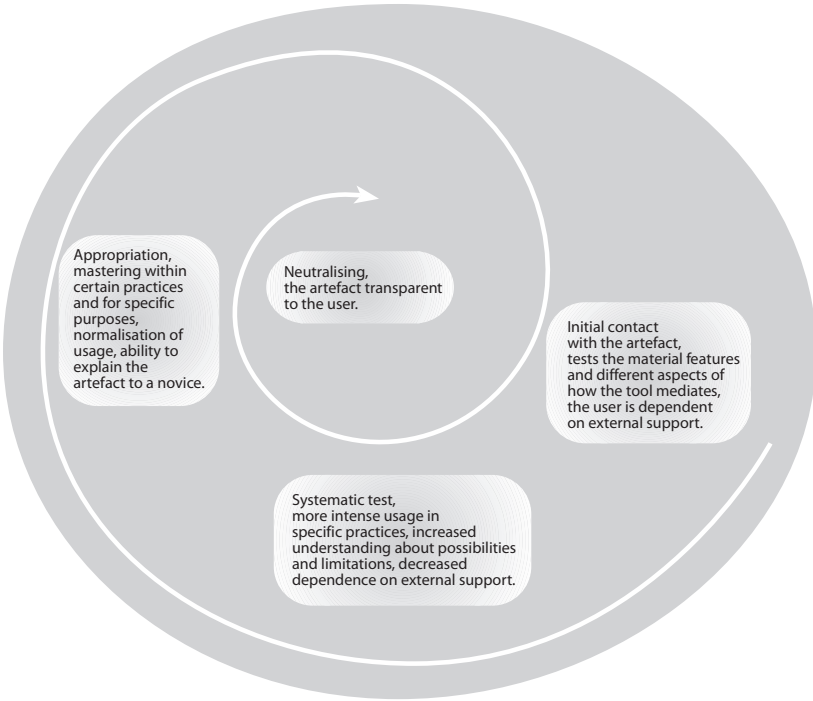

Figure 5. Säljö's model (2005) of appropriation through increased coordination between mediational means and subject (Author's translation).

According to Säljö (2005), our learning is initiated from a first encounter with a personal unknown artefact. This encounter could be the first time we see or use a tool such as a bicycle or a computer program. Importantly here is that these artefacts are encountered in specific situated activities. If there is further encounter with the artefact, Säljö describes the following use as more intense, where the user learns the prerequisites of the artefact. From this level follows an appropriation of the

artefact where this is seen as an incorporated part of a specific practise. Eventually, the artefact will be neutralized and taken for granted by the user. According to this model, the learning process consists of the learner's coordination of her way of thinking and acting. The initial contact with the unknown artefact involves, however, overcoming a resistance, since what is offered is not automatically accessible to the individual. The resistance emerges since these cultural products are not, per se, coherent to the learner's experiences and will be further discussed.

3.3.4 A sociocultural approach to learning in the context of science and technology centres

Within the field of science and technology centres as well as within other areas of voluntary activities, learning is often referred to as informal learning (e. g. Rennie & McClafferty, 1996; Livingstone, Pedretti & Soren, 2001). This can be seen in relation to the concept formal learning, which is commonly referred to as learning taking place in schools or in other formalised and organized institutions. However, there is an ongoing discussion about how to label learning that occurs in, or in relation to, for example, a visit to a museum or a STC. Apart from informal learning, this has also been referred to as learning in informal settings (e.g. Anderson, Lucas & Ginns, 2003) and extramural learning (e.g. Bagge, 2003) which refers to all learning that takes place outside school, both organized and unorganized. However, the distinction between informal and formal learning risks leading to an understanding of that there exist different kinds of learning processes and that these conclude with different learning products, according to Davidsson and Jakobsson (in press). Consequently this distinction risks focusing *where* and *in what context* learning occurs instead of emphasising prerequisites for learning and enhancing meaning-making processes, independent of place and organization. This risk is made explicit when Falk and Dierking (2001) argue that free-choice learning is a more appropriate label than informal learning, as this focuses on different characteristics of this kind of learning such as nonlinear, personally motivated and involving choices on the part of the learner as to when, where and what to learn. When discussing learning in free-choice situations, the authors argue that it is a great impediment that traditional formal learning models have been adopted in this area, as this suggests that people engaged in free-

choice learning should learn the same types and things and in the same manner as people do in formal situations.

From a sociocultural perspective, learning is understood as processes where humans appropriate collective experiences and knowledge. Kozulin (2003) argues that these processes can be described as natural and universal, as we are born with prerequisites to learn and we are therefore able to interact with artefacts or mediational means. This means that when using a sociocultural approach, it is impossible to distinguish different kinds of learning processes because they have their origin in different settings or contexts. However the content or the learning products are dependent on the culture or context in which the learner is a part of. But when discussing prerequisites for learning, according to a sociocultural perspective, what factors may be considered as influencing and facilitating appropriation? And in what ways is it possible to apply these factors in a STC setting?

Based on the previous discussion, the following section will outline five factors which could facilitate appropriation, but also relates them to visitors' learning from science and technology exhibitions. These factors are probably not the only influencing factors to facilitate appropriation, but they were found distinctive in the referred literature. Neither is there any hierarchically order between the factors and one factor is not considered as more important than another. The factors are: explicating an artefact's cultural-historical background, intentional introduction of the artefact, relevance, resistance and intentional mediation goals.

Explicating an artefact's cultural-historical background

Artefacts, as tools for goal-directed actions, do not exist in isolation, but only in relation to a situation, context, practice, etc. They thus derive their meaning in particular situations where cultural norms and values allow them to exist and develop. Artefacts normally mediate no meaning, if removed from the context that engenders them and fills them with purpose. Kozulin (2003) argues that if the context is poorly mediated to learners, there is a risk of losing the understanding of the artefact's functioning as a tool. If using this reasoning in the context of an exhibition, all artefacts put on display have initially been removed from their originally practice and thereby risk losing their value as mediating tools. The task when constituting a new exhibition is thus to reconstruct the cultural-historical environment and recreate the mediational potential that

used to engender the artefacts. For example, a common exhibit at many STCs displays refraction of light through different lenses. A way to emphasise the cultural-historical background could be to describe the way the lens has affected people's life historically as well as how people's thoughts and actions have affected the development and use of the lens. This means for example to highlight and discuss what the early lenses looked like, the consequences in society of that citizens were able to read also when having visual defects and how this influenced scientists, as for example Johan from Peckham (1220-1292) or Roger Bacon (1214-1295). It could also mean to emphasise the scientific language, concepts and theories related to the lens and its development. Through re-providing mediational qualities and displaying the artefact, here exemplified by the lens, in a rich cultural-historical context it creates prerequisites for visitors' learning in which they can appropriate the artefact as a tool.

An intentional introduction of the artefact

As discussed earlier, Kozulin (2003) stresses the importance of purposely introducing artefacts, in order for the learner to distinguish these from content material or empirical realities. If there is no intentionality, there is hence a risk that the learner may not recognise the artefacts and mix it with content material. Kozulin (2003) argues that the mediational means fills its purpose only when appropriated as a generalized instrument, capable of organizing cognitive and learning functions which can be used in different contexts. In what ways may this notion be used in the process of planning and creating an exhibition in order to facilitate visitors' learning? First, there is a need to identify what mediational means or artefacts that are desirable to introduce and distinguish them from content material. In an exhibition concerning, for example, ecology, the staff may want to display the relationship between the numbers of individuals of different species. Perhaps is it common knowledge that there exist very few eagles and many voles, but that is content knowledge unless it is related to an artefact. The identified artefact which may explain this relationship could, for example, be the nutrition triangle. A visitor may be intentionally introduced to this artefact, which describes not only the relationship between eagles and voles, but may also be used in other ecosystems in order to describe the relationship between predators and preys. Further on, this artefact can, for example, be used when

considering the amount of nutrition each individual within a specie demand for its existence.

Relevance

The third factor highlights the issue of whether the learner finds a personal relevance to appropriate the presented artefacts. Kozulin (2003) argues that artefacts such as symbols, diagrams and texts risk remaining useless to the learner, unless their relevance is mediated. This means that the mere availability of artefacts does not automatically conclude with appropriation of the artefacts. Within the field of STCs, there exists some models for studying visitors' learning (Stocklmayer and Gilbert, 2002; Falk and Dierking, 2000) which are discussed by Davidsson and Jakobsson (in press). One feature discussed in the PAST-model (Stocklmayer and Gilbert, 2002), is the importance of *remindings*. This means that the visitors need to encounter a familiar situation in order to increase their understanding of science. However, if using the previous reasoning, it risks being insufficient to only experience a familiar phenomenon and to be reminded of previous encounters, as the accessible resources put on display do not automatically lead to appropriation. This means that the relevance of an exhibit could increase by providing it with many possibilities to associate to the actual artefact and thereby satisfy different visitors with different backgrounds and experiences. This could be achieved by, for example, considering different aspects of science such as controversial issues or values in society (Davidsson, accepted) which young people often express an interest in.

Resistance

When a learner is presented with a new artefact, Säljö (2005) argues that appropriation of this artefact always involves resistance. This reasoning originally derives from the work of Bahktin (1981) who discusses how words may resist speakers' attempt to appropriate them. However, Säljö uses this notion for all artefacts as they are inaccessible as resources to a novice. This means that collective experiences that are included in the artefact are not automatically coherent with the experiences made by the individual. If investigating this notion in a STC-perspective, visitors are likely to encounter artefacts that they do not have previous experience of. This resistance arises because there are difficulties for the visitors to know what to look for and it is crucial to overcome this resistance in or-

der to enhance learning. The resistance could in some perspectives be related to the factor of *Relevance*, since if visitors do not find any relevance about a subject area this may lead to a resistance to learn. At the same time is it possible to experience both a relevance and a resistance concerning for example a complex or abstract subject matter.

Intentional mediational goals

The fifth and last factor concerns a consciousness about mediational goals. Wertsch (1998) argues that to be able to observe any development, it is crucial to posit a priori goals of where the development is headed. However, such goals are often implicit rather than explicit which risks leading to difficulties in revealing individuals' development. As a central aim of a STC is the enhancement of visitors' knowledge and interest in science, it is of importance to be able to assess and evaluate the visitors' development. A central point in the process of planning and constructing new exhibitions could therefore be to consider and clarify what learning goals the particular exhibit has. For example in an exhibition about global warming a goal could be to mediate the understanding of the relationship between the use of fossil fuels and the increase of the greenhouse effect or the circuit of carbon as artefacts. It is however possible to explicate different learning goals, as the visitors, who attend an exhibition, have different backgrounds and experiences.

3.4 Economic prerequisites and science exhibitions

The third hypothesis in this thesis is that economic interests affect how science is constituted and outlined in exhibitions. The results of the final study in this thesis conclude that sponsors are important revenue sources and, in many cases, crucial for the work at museums and STCs. Sponsors are defined here as economic contributions from both companies as well as from other sources of funding. This means that sponsors to a large extent provide resources for developing and creating new exhibitions. However, the analysis of the questionnaire, the observations and the focus group interview all reveal that sponsors may also directly and indirectly influence the exhibitions in different ways. Direct impact refers to sponsors' explicit demands on being visible in the exhibition or demands concerning the content or the design of the exhibitions. Indirect impact refers to implicit demands, as for example self-censorship,

in which staff members consider what they believe are views of the sponsors when planning the exhibition. This study thus concerns mot only the impact of sponsors, but what constitutes the economic conditions for STCs and museums?

Each year, the Association of Science and Technology Centres (ASTC) conducts a survey among its members concerning background variables of the individual institutions, programs offered, attendance, financial information and employees. In 2006, the survey was sent to all 428 members and 205 institutions responded, for a response rate of 48%. Most of the respondents come from the US (163 of 205) and only a small part (42 of 205) represents other countries. When it comes to financial information and economic conditions, STCs seem to be supported by a mix of operating revenue sources, which include public funding, private funding and earned income. Earned income refers primary to money earned from ticket sales and program fees. In addition, some STCs have endowments which generate interest and are used to support different projects.

If public funding and private funding are considered separately, earned income constitutes the largest percentage of operating revenue, both in the US and worldwide. In the US, public funding and private funding contribute to the operating venue to approximately the same extent (24.0% respectively 25.2%), whereas in other countries public funds play a more important part (ASTC, 2007). The division of different revenue sources is shown in Table 1.

Table 1. Operating revenue sources (ASTC, 2007).

	Earned income	**Public funds**	**Private funds**	**Endowment income**
US	45.7%	24.0%	25.3%	5.0%
Other countries	36.6%	46.2%	15.2%	2.0%
All respondents	**43.9%**	**28.3%**	**23.4%**	**4.4%**

Apart from being dependent on a mix of revenue sources, ASTC (2007) also concludes that many STCs also depend on in-kind support and more than 80% stated that they received it. The most common support was to receive public relations and advertising services. Furthermore, nearly one fifth stated that they received support for building maintenance and just as many stated that they got ground maintenance. More than 68% listed other contributions including computer equipment, exhibit material and program supplies. This also includes professional services such as legal, engineering, accounting, Web hosting, travel support and other services or goods. The division of different kinds of contributions is shown in Table 2.

Table 2. Various sources of in-kind contributions (ASTC, 2007).

Type of contribution	% reporting
PR/Advertising	68.5%
Building maintenance	18.8%
Grounds maintenance	18.2%
Utilities	13.3%
Other	68.5%

As seen in Table 1, about 40% of the earnings emanate from admission fees and program fees. Furthermore, American STCs say that about 50% of their revenue, on average, comes from funding while outside of the US this figure is above 60%. Also in-kind contributions are common and STCs seem to receive goods as well as support in several different service areas (Table 2). This means that STCs are dependent on incomes from both private and public funds in order to plan and create new exhibitions. This also means that these economic contributors as well as in-kind supporters may have opinions about the content and the design of exhibitions and may interfere in the process of constructing new exhibitions (Davidsson & Sørensen, submitted). But to what extent does the economic situation actually affect the choice of what aspects of science to display? Do staff members need to consider sponsors' demands closely or does the fact that 44% of the revenue sources, on average, come from earned income and thereby provide prerequisites for staff members to be less dependent on sponsors' opinions and demands?

4 SUMMARY OF THE RESULTS FROM THE STUDIES PRESENTED IN THE ARTICLES

The following summaries are only short descriptions of the results from the studies. A more detailed discussion about the results and implications is found in each article.

Different images of science at Nordic science and technology centres. (Davidsson & Jakobsson, 2007).
A common goal of STCs is to enhance visitors' interest and knowledge in science. But what different images and aspects of science are visitors confronted with at Nordic STCs? This article focuses on different aspects of science that are displayed and the ways in which these aspects may constitute different images of science. Staff members at Nordic STCs, who worked with planning and constructing new exhibitions, were therefore asked to consider statements about to what extent they believe they displayed different aspects of science such as science in a technical perspective, controversial issues or gender issues. They were also asked to consider to what extent they would like to display these aspects in a future exhibition. 66 respondents from 30 different STCs answered the questionnaire.

The results highlight the fact that depending on what aspects of science staff members choose to display, these constitute different images of science. A common image displayed in exhibitions is *the usefulness of science,* which tends to emphasise scientific and technical products and the usefulness of these products in society. This image is well in line with the critique within the field of STC research of displaying a too

narrow and single-dimensioned image of science. However, also another image appears in today's exhibitions and is referred to as *science and culture*. This image highlights aspects such as gender issues, historical issues and non-western cultures and may make explicit the humans behind science.

An evident result in this study was the discrepancy in what the staff members stated they displayed in today's exhibitions and in what they would like to display in future exhibitions. The analysis revealed three different images of science in future exhibitions, where the first was labelled *science, technology and culture*. This image accepts technology as an important part of a societal and cultural context. The second image, *science debate* concerned aspects such as values in society, controversial issues and how modern science is generated. This image emphasises argumentation as a part of scientific processes. Finally, *informative science* stresses conceptual knowledge as it highlights the aspects scientific facts and science in society.

Enhancing visitors' interest in science – a possibility or a paradox? A study of what scientific content staff members choose to display. (Davidsson, accepted to be published in Research in Science Education). The article focuses on how staff members at STCs consider what scientific aspects to include or exclude during the process of planning and constructing new exhibitions. It aims to discuss these priorities in relation to the concept of scientific literacy and young people's attitudes towards science. Staff members were therefore asked to consider how they choose what scientific aspects to include, but also how the aspects scientific processes and the relation between science and society, politics and economy were explicit to the visitors. The study is mainly based on interviews of 17 staff members who work with constructing new exhibitions at Swedish STCs.

The results suggest that staff members tended to discuss the scientific content in terms of organisational matters, such as what was possible to implement in limited exhibition areas, whether the exhibit was considered to be enjoyable or what material that was available for exhibit constructions. Furthermore, the analysis reveals that aspects such as the relation between science and society, politics and economy, as well as scientific processes, tend to be implicit to the visitors or seem to be represented only to a limited extent. The staff members express an anxiety in

displaying different reasoning or argumentations which are valid in different situations. They are thus likely to consciously avoid different explanatory models. Several respondents argue that displaying different researchers' points of view, or providing ambiguous answers, risks questioning the credibility of their museums.

However, these aspects of science are, in the field of science education, considered as crucial in order to create curiosity and interest in science. They are also important aspects for enhancing scientific literacy. There is thus a risk that these aims are left unfulfilled when exhibitions do not provide opportunities for visitors to discuss science in relation to different societal aspects.

Staff members' ideas about visitors' learning at science and technology centres. (Davidsson & Jakobsson, accepted to be published in International Journal of Science Education).

This article focuses on and investigates staff members' assumptions about visitors' learning. It also aims to explore how their reasoning intersects with existing theories about learning within the field of STC research. The data consists of interviews from 17 staff members who work with constructing new exhibitions at their STC. The analysis reveals that the staff members' referred to learning processes differently by distinguishing organised from non-organised learning, theoretical from practical hands-on learning and serious from non-serious learning. According to most of the respondents, these conclude with different learning outcomes. The results, furthermore, imply that staff members, to a large extent, tend to consider their own personal experiences when discussing visitors' learning. Some respondents, in addition, rely on their professional experiences, their professional education or external sources. However, eleven of 17 respondents explicitly state that they do not have any scientific knowledge about learning. This experience-based approach to learning risks bringing consequences to the staff members' views of visitors' learning. This means that they tend to consider learning only in specific situations and risk not to count enjoyment and experiences as learning.

When it comes to how the staff members' reasoning intersects with existing theories of learning this could be found to some extent. This means that a few of the respondents refer to the importance of communication to enhance visitors' learning, which is an important aspect in

the contextual model of learning (Falk & Dierking, 2000). Furthermore, some staff members discuss knowing about visitors' prior knowledge in order to understand how learning is developed through interactions with exhibits. This is also an important starting point in the PAST-model of Stocklmayer and Gilbert (2002).

Economic interests and science exhibitions – a study of how sponsors may affect exhibition content. (Davidsson & Sørensen, submitted).
This article aims to summarize the three previous articles by discussing different factors and underlying assumptions which affect how science is constituted and outlined in exhibitions. It further aims to explore how the staff members consider the impact of economic interests on a final exhibition. The data consists of a questionnaire sent to all members in the Nordic Science Centre Association (NSCF), interviews of 17 staff members, participating observations at a Nordic STC and a focus group interview.

The analysis reveals that sponsors are, in many cases, crucial for the work at the museums or the STCs. However, the results show that half of the respondents, who had sponsors involved in the latest exhibitions, experienced sponsor interference and found that sponsors had opinions about the content and/or the design of the exhibition. The results further suggest that that the issue about sponsors' impact on exhibitions is complex as they may influence the exhibitions directly and indirectly. Direct impact refers to sponsors' explicit demands of being visible in the exhibition or demands concerning the content of the exhibitions. Indirect impact refers on the other hand to implicit demands where staff members explain what they believe are views of the sponsors and these perceptions are expressed in the discussion about self-censorship. Furthermore, indirect impact also refers to when staff members already at the start of a project consider different possible sponsors and try to include them in the process of constructing an exhibition. This means that staff members seem to need to account for sponsors possible views and demands both in advance and during the planning of new exhibitions. The dependence of sponsors risks, according to Macdonald (1998), leading to a homogenisation of exhibitions where it is difficult to put specific demands. Furthermore, Gieryn (1998) point to the difficulty in including controversial issues in exhibitions while being dependent on sponsors.

5 DISCUSSION

The purpose of this thesis was to explore what underlying assumptions and what factors affect how science is constituted and outlined in exhibitions. It was, however, necessary to first obtain a general view of how science can be constituted in exhibitions. Therefore, in the study presented in the article *Different Images of Science at Nordic Science Centres* (Article I, Davidsson & Jakobsson, 2007), staff members were asked to consider what aspects of science they chose to display in their latest exhibitions, as well as to reflect upon what aspects they would like to display in a future exhibition. The results suggested that depending on what aspects of science staff members chose to display, these constituted different images of science. The most common image displayed was the *usefulness of science*, which emphasises the use we have for science in our society and displays only the good things humans have accomplished through science and technology. This means that this image tends to present science as an unproblematic and ready-made body of knowledge. Furthermore, the results revealed a discrepancy between what aspects of science staff members stated they display today and what aspects they would like to display in future exhibitions. Could this discrepancy be a result of an awareness among the staff members of that science tends to be displayed only through the image of the usefulness of science? This idea is supported by Tlili, Cribb and Gewirtz (2006). They explored how staff members, most of them science educators at two STCs, experienced the work of making the exhibitions more culturally and socially inclusive, relevant and engaging. The analysis of the interviews revealed that the staff members tended to feel unsatisfied about the dominant context-independent and universal way through which science was communicated in their exhibitions. In response, they

advocated exhibitions which focus on relevance, lifestyles and visitors' personal interests.

From the results, presented in Article I, it was however not possible to thoroughly explain *why* some aspects were more commonly occurring than others or *why* some aspects were less explicit than the staff members would like them to be. For example, why were not certain aspects, such as controversial issues or values in society displayed to a greater extent in present exhibitions? Were there underlying assumptions among the staff members or other crucial factors which affected how science is constituted and outlined in exhibitions? From the results of the study presented Article I as well as from the literature review, three possible influencing assumptions and factors seemed to be more significant than others; staff members' ideas about the nature of science, staff members' ideas about learning and economic interests. These assumptions and factors were posed as hypotheses in order to explore their validity.

5.1 Exploring the validity of the first hypothesis

The first hypothesis posed was that staff members' ideas about the nature of science affect how science is constituted and outlined in exhibitions. From the results, presented in Article I, it was evident that science tended to be presented in an unproblematic and single-dimensioned way in exhibitions. As such, these results confirm the critique of, for example, Pedretti (2002), Arnold (1996) and Frøland and Henriksen (2003). This was also evident in the study, presented in *Enhancing Visitors' Interest in Science – A Possibility or a Paradox?* (Article II, Davidsson, accepted) where the aspect of scientific processes tended to be either implicit to the visitors or represented to a low extent. According to the hypothesis in this thesis, this unproblematic way of presenting science could be a result of staff members who tend to hold limited views of the NOS. However, this does not seem to be the case.

The results from the study, presented in Article II, indicated that staff members, in general, hold a broad view of the NOS. This means that the respondents expressed a broad understanding of consensus explanations and the fallibility of scientific knowledge. Furthermore, the results indicated that the respondents, to a high extent, regarded values and ethical considerations as a part of science and also that science is embedded in

and influenced by our culture. These results are supported by Rennie and Williams (2002) as they found that the staff members in their study expressed a broad understanding of several features of the NOS in comparison to visitors' views.

It seems therefore that staff members are aware of the decontextualised and unproblematic image of science in exhibitions. Furthermore, it seems that they tend to feel unsatisfied about presenting such a limited image (Davidsson & Jakobsson, 2007; Tlili, Cribb & Gewirtz, 2006). According to the conclusions in Article II and Rennie and Williams (2002) it is not likely that this is a result of staff members generally holding limited views of the NOS. But what explanations could there be for the tendency to emphasise the image of the usefulness of science?

From the results of Article II it was evident that the respondents, to a large extent, discussed the scientific content in organisational terms. This means that the respondents, for example, focused on possible activities in relation to a limited exhibition area or on what was considered to be engaging and enjoyable. Could one possible explanation for the likeliness of presenting a narrow view of science be that practical matters are so immediate and demand direct actions, that there is no time left for discussing the scientific content in terms of what different aspects of science to display? It was not possible to conclude that from this study. But the results of Article II revealed another possible explanation for the discrepancy between what the staff members wanted to display and what actually was chosen to be presented. When the respondents expressed in what ways scientific processes were explicit to their visitors, the analysis revealed that this NOS aspect was represented to a low extent or that it tended to be implicit to the visitors. Several staff members expressed an anxiety in displaying different models of explanations or how the scientific community has reached consensus, because of the risk of confusing the visitors. Some respondents even argued that displaying different explanatory models or providing ambiguous answers, would question the credibility of their institutions. The results, presented in Article II, thus suggest that staff members risk making themselves guardians with respect to what the visitors ought to know.

Within science education NOS aspects are considered as important components when learning science (e.g. McComas, Clough & Almazroa, 2000; Rudolph, 2003). The previous section 3.2 *the nature of science and science exhibitions* furthermore highlights the importance of

making these aspects explicit to learners (e.g. Khishfe & Abd-El-Khalick, 2002). In order to address and focus on NOS aspects in science exhibitions, several scholars argue for an inclusion of socio-scientific issues (Pedretti, 2004; Bradburne, 1998). Also the staff members, who participated in the study presented in Article II, seem to consider socio-scientific issues as important ingredients in exhibitions and they argue that they display the relationship between science and society, politics and economy in their exhibitions. However, the analysis of the interviews revealed that this relationship tends to become implicit for the visitors. This means that socio-scientific issues, which derive from today's frontiers of scientific knowledge, that deal with incomplete information because of conflicting scientific evidence and address local and global dimensions with political and societal frameworks (Ratcliffe & Grace, 2003), risk being implicit aspects of science in exhibitions. As argued in Article II, there is a risk that if NOS aspects and socio-scientific issues are implicitly addressed in exhibitions, this could, instead of enhancing visitors' interest in science, create a detachment or disengagement about scientific issues.

5.2 Exploring the validity of the second hypothesis

The second hypothesis in this thesis was that staff members' ideas about visitors' learning affect how science is constituted and outlined in exhibitions. This means that their approaches to learning could affect decisions about what aspects of science to include or exclude in exhibitions.

In order to investigate the validity of the second hypothesis, it was first necessary to explore staff members' ideas about visitors' learning. From the results presented in *Staff Members' Ideas About Visitors' Learning at Science and Technology Centres* (Article III, Davidsson & Jakobsson, in press), it was evident that most respondents referred to their own personal experiences when discussing visitors' learning. This means that they, to a large extent, compared visitors' learning to how they themselves react when attending an exhibition. Furthermore, they tended to consider their professional experiences, which refer to knowledge from working with exhibitions, based on, for example, observations of visitors in what they do and what they ask about. Two thirds of the respondents argued that they did not have any scientific approach to describe visitors' learning.

The results are in line with those of Astor-Jack, McCallie and Balcerzak (2007), who investigated staff members' scientific approach to learning. They explored views of effective professional development held by eight providers representing four informal science institutions and four institutions within higher education. Seven of eight respondents had an educational degree at the graduate level and all of them had several years of experience of working with professional development. The results revealed that the use of language in relation to education tended to be more informal, experienced-based and individualistic among the staff at the informal science institution and more formal, theory-based and consistent across the staff at higher education. But what consequences could an experienced-based approach to learning bring?

As argued in *Article III*, there is risk that learning is only seen to occur in certain specific situations and that enjoyment and experiences do not count as learning. This is in agreement with the results of Rennie and Johnston (1995) who found that several explainers, who worked at a STC, stated that learning is not the main purpose of the visit. Instead some respondents argued that enjoyment and learning are two very distinct things. This reasoning implies that staff members risk not realising all of the possibilities for learning which could be provided to visitors. If considering a sociocultural approach, learning processes have their origins in all social and cultural interactions in which we participate and new thoughts could be mediated, independent of whether the situation is organised or non-organised, serious or non-serious or theoretical or practical hands-on (Article III).

Another consequence of an experience-based approach could be that staff members tend not to consider what is known about learning within the areas of research in science education or from learning and informal settings. Within the field of science education there is an ongoing debate about enhancing the role of dialogues in learning situations (e.g. Lemke, 1990; Sutton, 1998). Also within the STC movement, dialogues are increasingly considered as a means for enhancing visitors' learning from exhibitions (e.g. Allen, 2002; Ash, 2002; Crowley & Jacobs, 2002). However, some recent studies within STC research have revealed that staff members are likely to use a lecture oriented learning approach when conducting guided tours (e.g. Cox-Petersen, Marsh, Kisiel & Melber, 2003; Tal & Morag, 2007). Furthermore, the results indicated that

visitors, to a low extent, were engaged in discussions with peers and curators.

Yet another consequence of an experienced-based approach to learning could be that different scientific aspects risk not being considered in relation to learning when creating new exhibitions. As argued in Article II, staff members tended to view learning about scientific concepts and phenomena as more important than learning about scientific processes. This could mean that certain scientific aspects are not considered as important components in exhibitions and thereby risk being overlooked during the process of planning and constructing new exhibitions. This could also mean that certain aspects are seen as possible to implement in educational material despite the fact that the aspects were disregarded during the exhibit design. This is exemplified in the study of Tlili, Cribb and Gewirtz (2006). They explored two STCs' equality and diversity policies and practices and sought to interview staff members who worked with this aspect. Of the ten respondents, most of them worked at an educational department and only one with exhibit design. The authors conclude that issues of equality and diversity are, to a great extent, aspects confined to the educational department and not an issue of exhibit design. Is this conclusion also valid when it comes to other aspects of science which could be displayed in exhibitions? Is there a risk that certain aspects of science, which are considered crucial in learning situations or important in order to enhance visitors' interest in science, only are emphasised and applied after the exhibit is designed?

5.3 Exploring the validity of the third hypothesis

The third hypothesis in this thesis was that economic interests affect how science is constituted and outlined in exhibitions. This means that external funding and sponsors affect what scientific aspects staff members choose to display in exhibitions.

According to ASTC (2006), the STC movement is, to a large extent, dependent on external funding. On average, more than 50% of the revenue incomes of a STC come from external funding, both public and private. However, in Europe it seems that the situation is more diverse. According to ECSITE-UK (2001) some European STCs earn over 80% of their revenues from non-governmental sources, whereas others rely on governmental support for up till 90%. However according to ASTC

(2006) STCs outside the US, on average rely for up to 60 % on external funding. But do sponsors actually affect the content and the design of exhibitions? According to the results, presented in *Economic Interests and Science Exhibitions* (Article IV, Davidsson & Sørensen, submitted), sponsors may have impacts on exhibition contents, both directly and indirectly. This impact could bring consequences to the way science is constituted and outlined in exhibitions.

One possible consequence is that 'blockbuster' exhibitions, which surely will attract large audiences, are chosen instead of exhibitions that are more insecure and open-ended or are likely to turn to smaller audiences. This is seen in the results of Article IV, as it was evident that the staff members considered the sponsors' possible views before applying for money or when constructing an exhibition funded by external revenues. These results are supported by Alexander (1996), who explored the impact of funding on art exhibitions. Her results suggest that as the museums become more dependent on external funds, the exhibitions increasingly reflect the tastes of the fund sponsors.

Another possible consequence could be that STCs need to avoid displaying controversial matters. According to Alexander (1996) the sponsors in her study were likely to avoid funding controversial exhibitions. Also the results presented in Article IV, indicate that sponsors may influence the exhibition directly by, for example, explicitly demanding that controversial issues of radiation from cell phones should be removed. Furthermore, the results suggest that staff members tend to account for sponsors' views indirectly, resulting in self-censorship. This means that staff members seem to need to account for sponsors' possible views and demands during the planning of new exhibitions.

A more general consequence of the dependence on financial support and benevolence of others is what Macdonald (1998) labels a trend towards homogenisation. She argues that there is a risk that exhibitions increasingly would be similar when it comes to the content and design. Such trend could lead to a cultural lessening, where it is difficult to get funding for specific demands and minority interests.

5.4 Conclusions and implications

The research focus of this thesis was on the underlying assumptions and factors that affect how science is constituted and outlined in exhibitions.

This main question was highlighted from three different perspectives; Staff members' ideas about the nature of science, staff members' ideas about visitors' learning and the influence of economic interests. However, this does not mean that these perspectives cover all possible assumptions and factors which could affect the final result of an exhibition. From the results, presented in this thesis, it seems that the staff members' ideas about the nature of science do not have a decisive effect on what scientific aspects they choose to display in their exhibitions. It is however possible to conclude that sponsors may interfere both directly and indirectly with exhibitions and could thereby affect how science is constituted and outlined. Also when it comes to staff members' ideas about visitors' learning this seems influencing how science is constituted and outlined in exhibitions. As previously discussed, the results imply that staff members, to a high extent, tend to use an experience-based approach to learning and thereby risk not considering what is known from the field of learning and informal settings or from the field of science education. Furthermore, the results indicate that staff members tend to disregard aspects of science which within science education are considered crucial in learning situations in order to enhance the learners' interest and knowledge in science. Instead other studies (e.g. Tlili, Cribb & Gewirtz, 2006) imply that certain aspects of science such as, for example, equality and diversity policies and practices are considered belonging only to the educational field and not to exhibit design.

However, if considering a sociocultural approach to learning, visitors' learning is viewed as closely related to available artefacts in the exhibition. This means that if we want an exhibition to mediate, for example, that science is a multicultural endeavour, that science is affected by society issues or that science is empirically based it is necessary to recount for these aspects also during the process of planning and constructing the new exhibition. But in what ways is it possible to use a sociocultural perspective and the concept of mediation when planning an exhibition in order to facilitate visitors' learning?

The model of successive appropriation

In the previous section 3.3 *Learning and informal settings*, five factors were presented as possible influencing factors for facilitating appropriation of artefacts: explicating an artefact's cultural-historical background, intentional introduction of the artefact, relevance, resistance and inten-

tional mediation goals. The purpose of this section is to use these factors in order to suggest a model of learning from a sociocultural perspective, which could be applied in STC settings. As stressed earlier, there is no hierarchically order between these factors and one factor is not viewed as more important or crucial than another.

A starting point for this discussion is that when an artefact is removed from its original cultural milieu and put on display in an exhibition, it risks losing its mediational potential (Kozulin, 2003). The task is therefore, when constructing an exhibition, to re-provide its mediational potential in order to facilitate appropriation of that artefact. According to the previous discussion in section 3.3 *Learning and informal settings*, it is possible to affect and increase the artefact's mediational potential by considering and make explicit influencing factors, such as relevance or explicating the artefact's cultural-historical background. In addition of providing prerequisites for the appropriation of artefacts, it is also necessary to take into account the fact that the process of appropriation is time-dependent. Several encounters and continuing interactions with an artefact conclude with deeper understanding of its usage, its functions and under what circumstances the artefact works (Säljö, 2005). This means that within a specific practice, an artefact may also mediate new thoughts to a learner who are very familiar with this artefact, which can result in a new behaviour or a new way of reasoning.

On the basis of the five influencing factors, which were found distinctive in the literature and on that appropriation is time-dependent a new model of learning through interacting with artefacts was constructed. The model also has its origin in the conclusions from Article II and Article III which, for example, indicate that it is decisive to implement learning perspectives during the process of planning and constructing new exhibitions. This model, the *model of successive appropriation*, is illustrated in Figure 6 as a spiral, which has its origin in the first encounter with an artefact and heads upwards as the learner over time, successively appropriates more of the artefact's possibilities to be used as a tool in the specific context.

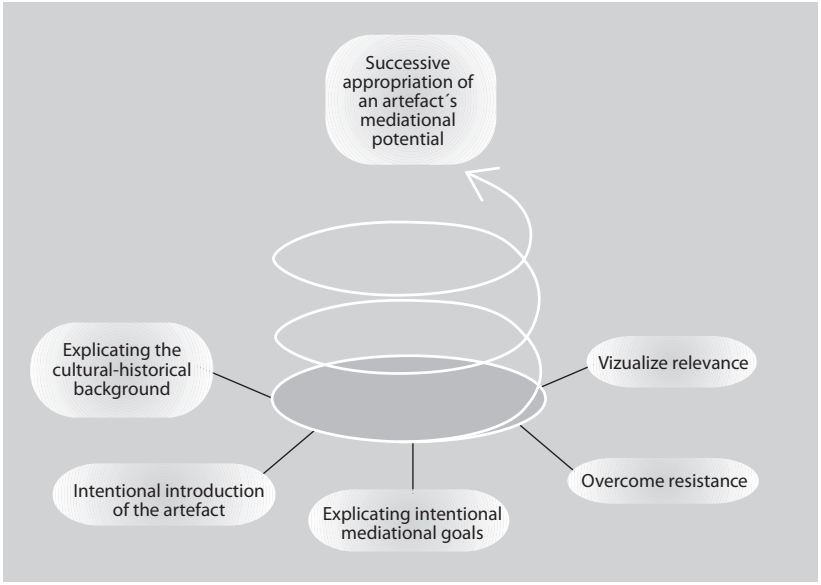

Figure 6. The model of successive appropriation of an artefact's mediational potential.

The five influencing factors, located along the base are not to be understood as only increased prerequisites during the learner's first encounter with the artefact. Instead these factors may always enhance the artefact's mediational potential and thereby increase the possibilities for further appropriation of the actual artefact. For example, if a visitor previously has encountered the secondary artefact of the atom model of Bohr and then interacts with exhibits, which aim to explicate its cultural-historical background and describe it in relation to other historical as well as contemporary atom models, such as for example, Dalton's, Thomson's, Rutherford's and Schrödinger/Bohr's models, this may lead to an increased understanding of Bohr's model or a successive appropriation of the atom model as an artefact.

The model of successive appropriation, which aims to describe learning through mediation from artefacts from a sociocultural perspective, could be used in exhibition contexts, both when constructing new exhibitions as well as when evaluating visitors' learning.

The model as a tool for planning new exhibitions

As argued previously, it is impossible from a sociocultural perspective to separate visitors' learning from available exhibits with which they interact. This means that all exhibits carry mediational potential, which to different extents affect visitors' appropriation of the displayed artefacts. All aspects of science, which the staff members refer to as important or want to focus on in a certain exhibition, must therefore be considered in advance, during the process of planning and constructing the exhibition. The *model of successive appropriation* could be seen as a support or a tool during this process in order to make explicit different factors, which could enhance exhibits' mediational potential and thereby have the possibility of influencing visitor appropriation of an artefact.

For example, if the factor explicating the cultural-historical background is taken into account, it could address questions such as: What scientific endeavours and what scientific processes preceded this artefact? Who constructed/invented/created this artefact and why was it an important contribution at that time? If instead the factor intentional introduction of mediational means is considered it could address questions such as: What specific artefacts do we want the visitors to perceive, discuss and interact with and how do we make these artefacts explicit throughout the exhibit? In what ways can we explicate the multiple use of an artefact in different contexts?

An exhibit's mediational potential could increase by taking more factors into consideration during the construction process. If the exhibit has the potential of mediating many different thoughts and handle different actions by the visitors, the exhibit could be referred to as a *rich exhibit*. An exhibit could thereby be described as having different levels of richness. This means that visitors could use the same exhibit differently depending on their previous experiences and encounters with the artefact. This also means that the exhibit has the possibility to turn to a larger audience and not only to a specific target group or age group.

The model as a tool for evaluating visitors' learning

A sociocultural approach brings consequences when it comes to what methodological considerations it is necessary to take into account when evaluating visitors' learning. According to this perspective, learning is not viewed as an isolated occurrence, but dependent on the available artefacts, tools signs, etc that have previously been discussed. This implies

that an evaluation of visitors' learning comprises individuals-acting-with-artefacts (Wertsch, Tulviste & Hagstrom, 1993). Considering that learning is situationally dependent, Säljö (2005) argues that it is decisive to study activities, how individuals act, what experiences they make and how they constitute meaning. In an exhibition context, it is hence possible to study visitors' learning through exploring ways they act and what they talk about when interacting with exhibits. It is also possible to use the *model of successive appropriation* and its influencing factors which could address questions such as: In what ways do visitors act in relation to mediational goals? How do visitors react to the intentional introduction of mediational means? And how does the richness of the exhibit affect visitors' possibilities to make associations?

Implications for the field of science and technology centres

This thesis aimed to explore the assumptions and factors which affect how science is constituted and outlined in exhibitions. It highlighted three different perspectives, which could provide a starting point for further investigations concerning the content and the design of exhibitions. The results also bring implications to the STC movement concerning the content and the design of exhibitions. One implication is that it is possible for STCs to display different images of science. This means that staff members could affect the displayed image of science by their choices of what aspects of science to include in their exhibitions. Another implication is that staff members may influence and enhance visitors' interest in science through their choices of scientific aspects by, for example, including socio-scientific issues. These issues could emphasise aspects such as ethical, controversial or philosophical dilemmas. It is crucial, however, that such aspects are explicit to the visitors and that exhibits carry the necessary mediational potentials. In the work of increasing the exhibits' mediational potential it is therefore important to consider and explicate learning goals during the phase of constructing new exhibitions. This means that different educational goals need to be integrated into different exhibits from the start, as the exhibits then may mediate these new thoughts to the visitors.

Yet another consequence of the results of the studies included in this thesis is the importance of considering a scientific approach, not only to the natural science content, but also to visitors' learning. A scientific approach to learning could, for example, more explicitly address learn-

ing goals and enhance prerequisites for visitor learning. This thesis, furthermore, suggests an approach to visitor learning through the model of successive appropriation. As described, this model can be used in order to increase the exhibits' mediational potential and thereby create increased prerequisites for constructing rich exhibits. The model could therefore be seen as a tool for addressing questions, during the construction of an exhibition, concerning the scientific content, the specific scientific aspects and visitors' learning. This means that the model may provide guidance for the content of an exhibition in terms of what aspects to choose as well as mediational and educational goals. To a higher extent, such parallel development, instead of first deciding on the scientific content and then suggesting learning goals, could bring an increased focus on visitor learning as well as on enhancing visitors' interest in science.

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RESEARCH REPORT

Different Images of Science at Nordic Science Centres

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Science centres aim to present science in ways that will attract visitors and enhance public interest in, and knowledge of, science. But what images and different aspects of science are visitors confronted with at Nordic science centres? This study aims to explore the different aspects of science that are displayed and the ways in which these aspects constitute different images of science. In this study, staff members who work with the planning and creation of new exhibitions were asked to answer a web-based questionnaire, identifying the extent to which different aspects of science were displayed in their latest exhibition. They were also asked to voice their opinions on what, and to what extent, they would like to display different aspects in future exhibitions. This study shows that exhibitions today, in particular, choose to display the wonders of science, presenting science in a product-oriented and unproblematic way. The study also reveals a great discrepancy between what staff members display at their latest exhibitions and what they want to display in future exhibitions. They express a will to emphasise aspects of science on the basis of a societal and cultural perspective. This means that controversial issues, values in society, non-western science, and scientific processes constitute important components for future exhibitions.

Keywords: *Science centre; Informal setting; Exhibition; Nature of science*

Introduction

Science centres worldwide aim to present science in ways that will attract visitors as well as enhance the interest in, and knowledge of, science. A number of research studies have been carried out in order to investigate the outcome of these institutions. A majority of these studies are related to learning outcomes and attitudes toward science (e.g., Heard, Divall, & Johnson, 2000; Nyhof-Young, 1996) or visitors' perceptions and interactions with exhibitions (e.g., Pedretti, Macdonald, & Gitari, 2001; Brook & Solomon, 1998). However, these studies do

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not discuss the foundations and assumptions on which staff members at science centres base new exhibitions and thereby convey messages of what science is. An important question is; what images and different aspects of science do visitors actually meet at a science centre? Is science presented as a dynamic, engaging, open, and multi-faceted subject area, or are ready-made, product-focused and stereotyped images shown? These questions formulate two extremes to how science can be presented and are not really possible to answer in any unambiguous way. Still, they raise some interesting and important questions for discussion. What images of science are possible to display at science centres and what constitutes these images? What aspects of science are chosen by the staff when exhibitions are constructed?

This article focuses on the aspects of science staff members believe they display in exhibitions and also the aspects they would like to display in the future. The aspects that the respondents considered derive from the ongoing debate about the nature of science. These aspects are presented in detail in the following sections. The article is the first part of a larger project that aims to explore the presumptions staff members have on communicating science through exhibitions. The study is based on a questionnaire of all staff members responsible for constructing exhibitions at 30 Nordic science centres. There is a lack of studies dealing with these issues, in the Nordic countries as well as internationally. This has made it necessary to obtain an overview of and a starting point for further studies. Future studies will be based on further triangulation of methods using interviews and participatory observation at Nordic science centres.

The Wonders of Science

Lately, museums and science centres have been criticised and questioned when science has been presented in a too narrow-minded way (Frøyland & Henriksen, 2003; Menved & Oatley, 2000; Pedretti, 2002). Pedretti (2002) contends that many museums and science centres just show "the wonders of science"; that is, an unproblematic, product-focused way that shows the "good things" we humans have accomplished through science. She argues that there is a need for change; a need for diverting attention away from the *wonders of science* to exhibitions related to contemporary and sometimes even controversial science. Such exhibitions enhance learning through an increased attention on context—not only the context in which science operates, but also the visitors' contexts. By promoting a public debate about science, and not just presenting scientific facts, it entails understanding the nature, processes, and achievements of science. It also entails critiquing the institution and practice of science (Pedretti, 2002). Other scholars argue for integrating experiences from museums or science exhibitions into the visitors' every-day life, linked to different social and cultural activities. This places scientific principles in more familiar contexts and could provide a starting point for reflecting on scientific issues that have an impact on decisions made in everyday practice (Jenkins, 2000; Menved & Oatley, 2000). Frøyland and Henriksen (2003) contend

that museums can and should to a greater extent turn towards society in order to contribute to an increased scientific literacy. By having exhibits about controversial themes and by using new methods to describe the themes, museums can reach a broader audience and thereby take a more active role in society. When young people are confronted with what is already known in science, without learning how we have come to know it, the understanding of social, cognitive, and epistemic dynamics is eliminated.

There is also a need to focus on the constructions and evaluations of knowledge claims, on the places where concepts and processes are shaped and take on meaning (Duschl, 2000). This does not only involve knowledge in science, but also knowledge about science, an understanding of the nature and status of science. Driver, Leach, Millar, and Scott (1996) describe this as being the way in which the body of public knowledge called science has been established and is added to, what our grounds are for considering it reliable knowledge, and how the agreement that characterises much of science is maintained. Also Rennie and Stocklmayer (2003) contend that science museums, to a greater extent, must try to reach people that never visit museums and suggest two aspects intended to increase public engagement. They suggest that science centres need to seek and involve the public's views through debate and consensus, and also initiate outreach activities. In another study, Rennie and Williams (2002) found that staff at an Australian science centre had different understandings of what aims the science centre should have. Two thirds believed that one important aim was to influence the images of science the visitors had before their visit. But almost one-half of the staff thought that the main aim was to display science and science applications. Rennie and Williams found that the staff was generally content with the positive exhibition impact on visitors, but some also felt that there was room for improvement when it came to presenting the nature of science and controversial issues.

Images of Science

If scientific products and facts are the main aspects of science that one can expect to find in a science exhibition, as Pedretti (2002) argues, what is then the unexpected? Ogawa (1998) stresses that science, as it exists in different communities, is interpreted and constructed by its citizens on the basis of the context and the culture in which they live. From the citizens' experiences, science is a constructed image believed to be culture independent. He contends that there are no culture-free interpretations of science. Different ways of presenting science can always only be interpretations of what science is actually about. What implications does this argument bring to the science centre movement and what aspects of science risk to be underrepresented? For example, Hodson (1998) talks about *learning about science*, where there is focus on acquiring knowledge and understanding of the processes and subprocesses of scientific inquiries. This involves learning about different strategies and tactics used by scientists, in order to understand different phenomena. He also stresses the importance of understanding the role of evidence

in scientific knowledge building. Also, Lemke (1997) emphasises the subprocesses and the role of evidence by arguing that learning science is to learn about how we re-make our views about the world. This argumentation is crucial, when scientists in different research communities publish and discuss results and evidence. These discussions lead to a greater acceptance for explanations of a certain phenomenon and eventually also consensus in the actual issue. Sutton (1998) also discusses the importance of learning about how we reach consensus. He contends that the language used for argumentation has changed gradually over time and is now to a great extent detached from the humans behind science. This leads to losses in educational points of view as it gives a very misleading impression of how new knowledge has been established. To make these issues explicit in science exhibitions one would need to display scientific uncertainties and the humans behind science. There are numerous examples of competitive explanations in history and here it is also easy to see the humans behind the discoveries (e.g., the different theories of natural selection held by Lamarck and Darwin). Likewise, it is not hard to find uncertainties and controversies in contemporary scientific debate that can be emphasised in exhibitions. The humans behind new findings, as well as how consensus is reached, are part of the public debate and less seldom discerned in scientific exhibitions.

Another area for discussion is the importance of science in society and also the view of science as an objective search for truth that is undergoing change. Driver et al. (1996) describe *science as a social enterprise*, which involves the understanding of science as an institution, embedded and controlled by society. Sjøberg (1998) also emphasises science as being part of society when discussing the relationship between science and, for example, technology, ethics, or politics. Decisions concerning scientific or technological development are taken on the basis of particular interests in society that are of benefit to some and perhaps at the expense of others. One part of a scientific exhibition could display these tensions of different political, economical, or ethical interest groups in society; for example, the tensions between the tobacco industry and health organisations or between the car industry and different environmental groups. Another possibility is to make explicit the decisions and positions that provide the foundation for how research funding is dispersed.

There are also several examples in *science history* where values and beliefs in society that have affected scientific thoughts can also be displayed in science exhibitions. For example, religions beliefs played a big role for the acceptance of scientific explanations when Galileo argued in favour of the heliocentric view and was forced to withdraw his findings and apologise to the church. Today there are many communities worldwide that do not accept certain scientific explanations in favour of religious ones. Also, in modern societies, subcultures have created their own explanations through their shared experiences, values, and beliefs (Aikenhead, 2000). This can be seen, for example, in the United States, where different religious groups do not accept the theory of evolution as the only explanation or even a valid explanation to understanding the origin of species. All these examples are meant to relate science to

other phenomena in society and make explicit that science does not only consist of scientific products, but is also a part of, is affected by, and affects our society.

Different cultures have also affected and still affect the apprehensions of *gender issues*. Several research reports show large gender differences concerning, for example, the interests in different science areas, an unequal division of men and women, where more men enter into scientific and technical educations (OECD, 2003; Sjøberg, 2000; TIMSS, 2003).

Through language, another consideration of the gender issue and science becomes clear. Hughes (2004) argues that gendered dichotomous thinking, which is an inheritance from the seventeenth and eighteenth centuries, is still present in associations where physics is seen as masculine, hard, objective, abstract rationality, whereas social and human sciences connote a feminine, more subjective, and softer approach. The abstraction and objectivity of pure science is then associated with masculinity while the contextualised approach relates to femininity.

Also, Keller (1992) discusses gender issues on the basis of language. She points to this perspective when illustrating the way scientific constructs, related to the female egg, are described with words such as "passive", "is transported", "drifts", and "is penetrated". Words such as "active", "self-propelled", and "penetrates" were related to the male sperm. Keller contends that by investigating the symbolic aspects of masculinity in science, gendering of science as a social construct rather than being biologically determined is revealed. Exhibitions can create an awareness of gender as a social construct. Also, hierarchies related to gender issues in science can be emphasised, for example in scientific concepts related to language.

A wider societal perspective of science can also incorporate *science from non-western cultures*. As mentioned earlier, Ogawa (1998) and Riess (2004) argue that there exists no single, universal, a-cultural science, but instead all sorts of sciences are ethnosciences. This is based on the fact that interpretations of our world are made by scientists, through senses affected by themselves as persons and their cultures. Even Aikenhead (2000) promotes the view of science being affected by the existing culture, and argues that western science is one of many subcultures of Euro-American society. Cobern and Loving (2004) discuss the importance of indigenous knowledge, both historical and present. They argue that it is of great value, since it broadens what is taught as science. In science exhibitions, science from non-western cultures could illustrate ways in which science is affected by the culture it operates in.

In this study, aspects of science refer to the different foci an exhibition can have. As already mentioned, an exhibition could, for example, focus on the wonders of science, learning about science, science as a social enterprise, science history, gender issues, or science from non-western cultures. It is of course impossible to display everything within a subject area at an exhibition. Each exhibition is a result of conscious or unconscious choices, made by staff members concerning different aspects of science. The aspects of science will be used to analyse different and possible connotations that exhibitions at science centres choose to express. In this way, comprehensive *images of science* can be described. These images thus depend on how exhibitions are constituted.

The Study

In the previous section the authors discussed how science generally can be manifested by relating science to historical, social, and cultural perspectives. However, their arguments are not usually based on empirical studies, but instead elucidate the ongoing debate about these issues. A problem in the science centre enterprise is the lack of studies that investigate how science can be manifested and displayed, and thereby convey messages to the visitors about what science is. This means that we today have insufficient knowledge about what aspects of science are presented in exhibitions. Therefore this study aims to explore different aspects of science that are displayed at Nordic science centres and how these aspects constitute different images of science. That is, to study staff members' own understanding of the extent to which they display and would like to display, different aspects of science. The research questions in this study are:

- What aspects of science do staff members display in their present exhibitions?
- What aspects of science do staff members express they would like to display in future exhibitions?
- In what ways do these aspects constitute different images of science?

The Questionnaire and Methodological Considerations

The reason for choosing a questionnaire in this study was to obtain a general view of the different aspects of science that were displayed, but also a will to attend to the lack of empirical studies in the area. The questionnaire aimed at collecting data from staff members working at different science centres, spread over a large geographical area, in the Nordic countries, during a relatively short period of time. It also made possible statistical analysis of the data. To be able to answer the research questions, the questionnaire was developed in order to ascertain to what extent the staff members apprehended that different aspects of science were displayed in present exhibitions. They were also asked to consider to what extent they would like to display the same aspects in a future exhibition. The aspects in the questionnaire have their origin in the previous discussion about what science can be. This means that aspects such as "science in society", "values in society", and "controversial issues" derive from the discussion about *science as a social enterprise*, where science is seen to be influenced by, for example, economy, ethics, and politics. The aspect "how modern science is generated" derives from *learning about science*. "Gender issues", "science from other cultures than our own", and "science in a historical perspective" were discussed separately. Finally, "scientific facts", "science in a technical perspective", and "experiences of everyday phenomena" have their origin from the critique of Pedretti (2002), arguing that science centres only displayed "the wonders of science".

Since the respondents only were asked to consider a limited number of aspects there is an obvious risk that the questionnaire only enlightens a part of the problem. The chosen aspects are of course not the only ones that can be displayed and it is

likely that other aspects of science would enhance an image or even constitute other images of science. Even though the result may be affected by these circumstances, the goal has above all been to cover a broad view of the ongoing debate. This study is therefore just the first part of a larger project that aims to explore what presumptions staff members at science centres have when they communicate science through exhibition displays. That is to make explicit the presumptions which the staff members take for granted as members of the science centre culture. In this way, this study also aims at providing indications for further research. Thus is this survey a part of a method triangulation where ethnographical methods such as participating observations and interviews will be included.

The selection of respondents includes directors of the science centres, and staff members working at the centres with developing and creating new exhibitions. A web-based questionnaire was sent to 88 persons, and more than 75% (66 persons) answered. In all, staff members from 30 science centres participated in the study. This means that all Nordic science centres, members of the Nordic Science Center Association (NSCF) have participated in the study. The respondents were asked to answer questions concerned with the extent to which they considered that the latest exhibition at their science centre displayed different aspects of science. They answered every question on a five-grade scale from "*to a very low extent*", represented by 1, to "*to a very high extent*", represented by 5. The questions were focused on the extent to which the staff members considered the latest exhibition to display the following:

- Scientific facts.
- Science in society.
- Experiences of everyday phenomena.
- Gender issues.
- Science from other cultures than our own.
- Controversial issues.
- How modern science is generated.
- Values in society.
- Science in a historical perspective.
- Science in a technical perspective.

The staff members also considered the same aspects of science, relating these to what they preferred to display in future exhibitions. The purpose was to make the staff members' intentions explicit and to analyse possible distinctions between the desires to present different aspects in future exhibitions and what was actually being displayed.

Analysis

Through the statistical analysis, both the individual respondents' apprehensions and the mean values of the aspects became evident. This was, however, not sufficient, since it could only account for each aspect separately. The question was whether these aspects, on the basis of the data, could be combined in order to constitute

different images of science. In the theoretical background some aspects seemed to be more frequently occurring than others, when presenting science (e.g., scientific facts, science in a technical perspective, and experiences from everyday phenomena). From the first analysis, the mean values also made explicit that some clusters of aspects had higher values than others. This pointed to the fact that some items in the data were interrelated. This interrelation can be visualised through principal component analysis, which reveals latent relationships between items. In conducting principal component analysis, the orthogonal rotation Varimax was chosen. This brought out groups of items (aspects), which indicated that the exhibitions displayed certain aspects of science in favour of others. In such a group, the aspects constitute what in this study are described as images of science. To measure the reliability of the questionnaire (i.e., to find out whether the aspects were really interrelated), the value of Cronbach's alpha was calculated. A value above 0.70 is an acceptable value, but a value just below this can also be realistic due to the diversity of what is being measured (Field, 2005).

Results

Images of Science in Present Exhibitions

The first analysis showed big differences in the extent to which aspects of science are displayed. Table 1 illustrates that the considerations of what was displayed were divided mainly into two extreme groups of aspects, one with high, and one with low mean values. Only one aspect, "science in a historical perspective" (3.22), was found in-between these extremes. The highest mean value was related to "experiences from everyday phenomena" (4.09). When analysing how the individual respondents answered, the dispersion related to this aspect was low. Other aspects with high mean values were "scientific facts" (3.94), "science in society" (3.89), and "science in a technical perspective" (3.69). For these aspects the dispersion of answers was slightly higher.

The low mean value group contained five aspects. The lowest mean value was related to "science from other cultures" (2.09). Nearly all the respondents experienced that their exhibitions displayed this aspect to a very low extent. The other aspects in this group were "gender issues" (2.77), "values in society" (2.75), "controversial issues" (2.60), and "how modern science is generated" (2.59). Among these aspects the dispersions of answers was large, with few answers in the middle of the scale.

The analysis pointed to two main clusters of aspects that represent latent factors. This implies that a number of hidden relationships were made evident. These relationships can mediate different images of science that the exhibitions convey (see Table 2).

The first factor, *the usefulness of science*, contains the aspects "science in society", "science in a technical perspective", "how modern science is generated", and "scientific facts". The aspect "science in society" had the highest correlation within this

Table 1. Mean values for the extent each aspect of science was displayed according to the respondents' assumptions about their latest exhibition

In what extent do you think the latest exhibition displayed:	*M* values, latest exhibition	*SD*
Experiences of everyday phenomena	4.09	0.84
Scientific facts	3.94	1.11
Science in society	3.89	0.95
Science in a technical perspective	3.69	1.10
Science in a historical perspective	3.22	1.24
Gender issues	2.77	1.30
Values in society	2.75	1.11
Controversial issues	2.60	1.25
How modern science is generated	2.59	1.15
Science from other cultures	2.09	1.06

factor. A probable connotation, in line with "science in a technical perspective", is that this kind of exhibition mediates the usefulness of technical achievements in our society. The aspect "scientific facts" emphasises science as a foundation for scientific products. By describing science mainly through the explanation of concepts and theories, there is a risk that science is displayed according to the wonders of science (Pedretti, 2002). This means that science risks to be portrayed in single-dimension and authoritarian ways (i.e., all questions have one correct answer).

The aspect of how modern science is generated emphasises scientific processes. But when related to the other three aspects within this factor, the usefulness of scientific products is emphasised through scientific processes. The aspects reinforce and increase the image of science as being concerned with the usefulness of scientific products in our society. On the basis of this analysis, an explicit image of science appears, *the usefulness of science*. Mainly this image conveys the usefulness we, as individuals or as a society, can gain from science. It can also conveys all the good that can be achieved through science, without discussing problems related to these technical and scientific achievements. Three of these aspects had high mean values, and a probable interpretation is therefore that this is a common image shown at Nordic science centres.

Table 2. Images of science displayed in present exhibitions

The usefulness of science	Science and culture
Science in society (0.81)	Gender issues (0.79)
Technical perspective (0.77)	Science from other cultures (0.77)
How modern science is generated (0.70)	Historical perspective (0.58)
Scientific facts (0.61)	

The second factor, *science and culture* (see Table 2), consists of the aspects "gender issue", "science from other cultures", and "science in a historical perspective". The aspect "gender issues", has the highest correlations within this factor. Gender issues can be related both to existing norms and values in society as well as in the scientific community. By relating to gender issues, the implication is that science consists of more than just concepts, figures, theories, and scientific applications. In this way science can be related to the existing inequity between men and women. It can also make explicit the women and men behind scientific findings. Hughes (2004) argues that there is a risk in describing science without this perspective is that science is displayed in an inhuman way, where science seems to be unaffected by interpersonal relationships and conflicts.

By displaying the aspect of science from other cultures, it is possible to convey the belief that science is of wider concern than just being aimed at an elite group of white, western men (Aikenhead, 2000). It can also in this way make explicit the gap between western science that operates in rich, developed countries and science in Third World countries. Through the historical perspective, science of today can be compared with science in a historical context. This is also elucidated when displaying different understandings of historical phenomena. An exhibition can, for example, stress the nature of science and how scientific knowledge becomes established through anomalies and scientific disputes (Sutton, 1998). These three aspects together, as illustrated in Table 2, interrelate and create the image *science and culture*. According to the mean values in Table 1, this image is less commonly occurring in exhibitions today. *Science and culture* connotes that science is affected by women and men that live and have lived, and thereby makes science an integral part of our culture.

The two images *the usefulness of science* and *science and culture* (see Table 2) describe how the aspects interrelate and constitute different images of science. The figures represent how well correlated each aspect is to the factor in the analysis; where 1 is the maximum and –1 is the minimum (0 is absolutely no correlation, whereas –1 is a directly opposed correlation). In a reliability test, *the usefulness of science* gets a Cronbach's alpha value of 0.70. *Science and culture* gets a Cronbach's alpha value of 0.59, which is an acceptable value (Field, 2005).

Images of Science in Future Exhibitions

The respondents were asked to reconsider the 10 aspects of science, relating these to the extent to which they would like to display them in future exhibitions. The intention was to make explicit the respondents' own desires to display different aspects. It also aimed at describing possible differences between how science is displayed today, compared with how the respondents themselves stress certain aspects. The results show, as illustrated in Table 3, that the mean values for each aspect is higher when compared with the respondents' views related to the extent to which these aspects were displayed in their latest exhibition. A probable explanation is that there is a greater will to present different aspects than perhaps is

Table 3. Mean value for the extent to which the respondents would like to display each aspects of science in future exhibitions

In what extent would you like a future exhibition to display:	*M* values, future (latest) exhibition	*SD*
Experiences of everyday phenomena	4.48 (4.09)	0.61
Science in society	4.29 (3.89)	0.77
Scientific facts	3.98 (3.94)	0.93
Gender issues	3.98 (2.77)	0.89
Science in a technical perspective	3.98 (3.69)	0.82
How modern science is generated	3.97 (2.59)	0.86
Controversial issues	3.94 (2.60)	0.93
Values in society	3.91 (2.75)	0.76
Science in a historical perspective	3.86 (3.22)	0.86
Science from other cultures	3.75 (2.09)	0.91

possible. Despite this, there are big differences between how the respondents actually display the aspects and the extent to which they would like to display them.

In Table 3 it can be seen that the aspect "experiences of everyday phenomena" has the highest mean value (4.48) related to what the respondents would like to display. It also has a very low dispersion of the answers. Other aspects that have high mean values are "science in society" (4.29), "scientific facts" (3.98). and "science in a technical perspective" (3.98). These were the same aspects the respondents believed their latest exhibitions displayed to a high degree. There is thus both a statement that these aspects are displayed in present exhibitions and that there is a will to display them in future exhibitions. Some aspects have relatively low mean values related to the matter of what is actually presented, but have high mean values when it comes to what the respondents would like to display. In other words, these aspects represent perspectives that the respondents express are not sufficiently evident in present exhibitions. For example, "gender issues" has a high mean value (3.98) in matters related to future exhibitions, compared with what is actually displayed (2.77). This is also true for how modern science is generated, as well as matters having to do with "controversial issues". "Science from other cultures" has the lowest mean (3.75) and is thereby the aspect the respondents would like to stress least of all in future exhibitions. This aspect has the lowest mean value related both to present and future exhibitions. "Science in a historical perspective" has the second lowest mean value (3.86) related to future exhibitions. In present exhibitions, this aspect has a relatively higher mean value compared with the other aspects, pointing to the fact that the respondents to a higher extent prefer emphasising other aspects of science in future exhibitions than the historical perspective.

The principal component analysis was again used to distinguish hidden relationships in the data. Here the results point to the fact that, even when it comes to the

respondents' own will to display certain aspects of science in future exhibitions, there exists clusters of aspects. Here, three different clusters became evident, which are illustrated in Table 4.

The first factor, *Science, technology and culture* contains a combination of aspects that are almost the same as the previous image *science and culture*. It consists of the aspects "science from other cultures than our own", "gender issues", "science in a historical perspective", and "science in a technical perspective". As mentioned earlier, the image *science and culture* connotes that science is affected by past and present men and women in our society, and is thereby a part of our culture. An interesting difference, related to what the respondents would like to display, is the addition of "science in a technical perspective". In *the usefulness of science*, the technical perspective is related to the use humans have of science in our society. When it comes to the image *science, technology and culture*, the technical perspective can take on another meaning, since it is related to other aspects. These aspects can emphasise humans behind science, the influences of society and the fact that science is of wide concern in our world. In this way, the technical perspective can connote that it is part of as well as affected by our culture. *Science, technology and culture* implicates placing science and technology in a human context, related to past and ongoing trends in society, pointing towards the intention of not only displaying technology in terms of figures, facts, and the usefulness of technical devices.

From the analysis, two other clusters of aspects also appear and consequently create two images of science. The second factor of concern to what the respondents would like to display is *science debate*. As seen in Table 4, it consists of the aspects "controversial issues", "values in society", and "how modern science is generated". "Controversial issues" have the highest correlation within this factor. This aspect, along with "values in society", can connote conflicting socio-scientific issues related to contemporary science and scientific research (Driver et al., 1996). This discussion can be further deepened through considering the aspect of "how modern science is generated", as it accentuates scientific processes (Hodson, 1998). In *the usefulness of science*, this aspect has a product-oriented focus and could display how to develop new products. In *science debate*, scientific processes are emphasised through socio-scientific issues. An exhibition of this kind can connote that science is also about debate, argumentation, and the submission of evidence (Lemke, 1997). Questions about what

Table 4. Images of science related to how the respondents would like to display science in future exhibitions

Science, technology and culture	Science debate	Informative science
Science from other cultures (0.87)	Controversial issues (0.85)	Scientific facts (0.88)
Gender issues (0.66)	Values in society (0.78)	Science in society (0.80)
Science in a historical perspective (0.63)	How modern science is generated (0.69)	
Science in a technical perspective (0.57)		

kind of scientific research we need and what the consequences are for humans and our environment can convey the view that science is affected by ongoing discussions in society.

The third factor (see Table 4) is *informative science*. It contains the aspects "scientific facts" and "science in society". The aspect "scientific facts" has the highest correlation within this factor. This aspect can be illustrated through figures, explaining concepts, and describing measurements, laws, and theories. Scientific facts can describe knowledge already proved and considered valid, leaving little room for discussion. "Scientific fact" is combined in this factor with "science in society", which can connote the usefulness of science in our society. Here this is done without considering a technical perspective or how modern science is generated, as in *the usefulness of science*. An exhibition based on scientific facts and science in society risks regarding science in a narrow-minded way, where much within science is excluded (Menved & Oatley, 2000; Pedretti, 2002). In a reliability test, the values for Cronbach's alpha are 0.72 for *science debate*, 0.74 for *science, technology and culture*, and 0.60 for *informative science*.

Discussion

The results of this study point to two images that are mainly presented in exhibitions at Nordic science centres. The image *the usefulness of science* displays science primarily in a product-oriented way through presenting the usefulness of technical achievements in society. As such, this image confirms the critique from Pedretti (2002) and from Frøyland and Henriksen (2003).

However, the results of this study point to a more complex and multi-faceted image. Through statistical analysis, it becomes evident that even scientific processes are made explicit in exhibitions. According to the staff members, the scientific processes become explicit through displaying scientific products and scientific applications in a societal perspective. But Duschl (2000) contends, that if scientific processes are to be understood, they also need to include the constructions and evaluations of knowledge claims and how consensus is reached in the research community. Seen in this perspective, scientific processes, as presented in *the usefulness of science*, risk to be displayed in an insufficient way.

The second image is *science and culture* and expresses science from a gender, historical, and non-western perspective. The mean values of the aspects are proportionately low, which also indicates that this image does not occur frequently. Many scholars (e.g., Hughes, 2004) argue that the aspects in this image are often lost when presenting science, but are at the same time important parts in the need to increase an interest for science and technology. Exhibitions that contain the image *science and culture* can in this way contribute to questioning this stereotyped perspective of science (Ogawa, 1998; Riess, 2004). This image of science also incorporates science from non-western cultures. The image *science and culture* also makes explicit the humans behind science, creating opportunities to display a more human image of science (Sutton, 1998).

An explicit result in this study is the evident differences in staff members' assumptions of what is actually displayed and what they would like to see presented in future exhibitions. On the whole, all aspects of science acquire higher mean values in future exhibitions. One explanation is the will to display as many aspects of science as possible. But at the same time some aspects diverge and acquire a significantly higher mean value in future exhibitions than others. Some examples of these kinds of aspects are "science from other cultures", "how modern science is generated", "controversial issues", and "gender issues".

An important question is why staff members experience some aspects as less explicit as they would wish. What probable explanations can there be for this phenomenon? Are these aspects of science not accepted in the scientific community? To what extent do sponsors affect the content of exhibitions? Is there a fear of being accused of taking positions in sensitive questions about science? Questions of this kind are outside the frame of this study, but are at the same time crucial to understanding the images of science that are displayed at science centres.

The analysis of what staff members would like to see presented in future exhibitions reveals three main images. The first image *science, technology and culture*, accepts technology as an important part of science in a human context, affected by our society and culture. A possible interpretation of this image is the intention of emphasising gender issues and science from other cultures through a historical and technical perspective. The significance of displaying this image of science is confirmed by Driver et al. (1996) and Sjøberg (1998).

The second image in future exhibitions is *science debate*. This image elucidates the importance of displaying socio-scientific issues by stressing the aspects "controversial issues", "values in society", and "how modern science is generated". This is also confirmed by Rennie and Williams (2002). Several scholars (e.g., Menved & Oatly, 2000; Pedretti, 2002) have called attention to the importance of controversial issues in science. Furthermore, Frøyland and Henriksen (2003) contend that exhibitions about controversial themes can reach a broader audience and thereby contribute towards playing a more active role in society. There seems to be extensive agreement concerning this issue, where staff members and researchers in science education would like to see more socio-scientific issues related to contemporary and controversial science. An important question is as follows: What prevents science centres from displaying this image of science? Even this question can provide a base for future research in this area.

The third image, *informative science*, contained the two aspects "scientific facts" and "science in society". An exhibition based only on these aspects risks regarding science in a narrow-minded and unproblematic way, similar to what Pedretti (2002) described as "the wonders of science". In this image much within science is excluded.

This study has pointed to the existence of two main images of science when science is displayed at Nordic science centres. It is above all a narrow-minded and product-oriented image of science that is evident, where scientific processes in many respects are absent. The study also reveals a discrepancy among the staff members'

thoughts related to what their latest exhibitions displayed and what they themselves would like to see displayed in future exhibitions. The result has made explicit the existence of different images of science. Images that appear in science exhibitions depend on what aspects staff members decide to display. However, in this study the respondents considered a limited number of aspects, which can have resulted in some images not being made explicit. Nor has it been possible to analyse the underlying causes of why these images of science are used. An increased understanding of the implicit presumptions about science and learning about science will require additional studies. Future studies should thus be directed towards finding explanations for the pertinent differences that exist between what is presented today and what staff members themselves find desirable to display in future exhibitions.

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II

Enhancing visitors' interest in science – a possibility or a paradox?

A study of what scientific content staff members focus on when planning a new exhibition

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Abstract

Within the enterprise of science and technology centres there exists explicit aims and ambitions to enhance visitors' interest in and knowledge about science. Meanwhile, several researches question the choice of the scientific content in exhibitions when arguing that a too unproblematic view of science commonly is presented. But how do staff members consider what scientific content to include and how this content can be organised in exhibitions? The results from interviews of staff members, responsible of planning and creating new exhibitions, suggest that they consider the scientific content of their exhibitions to a high extent in terms of organizational matters. This means that the staff members tend to not consider discussions about what aspects of science to include or exclude. Further on, the results imply that the relation between science and society risk being implicit to the visitors, whereas the aspect of scientific processes tend to be overlooked when constructing new exhibitions. The staff members express an anxiety in displaying scientific uncertainties or different models of explanations when arguing that this risk confusing the visitors. However, these aspects of science are, in the field of science education, considered as crucial in order to create curiosity and interest in science. Does this mean that science and technology centres, through their eagerness of enhancing visitors' scientific literacy, instead risk contributing to create detachment or unconcern about scientific issues?

Introduction

Already in the late 1960s, Oppenheimer (1968) argued for the increasing need to develop public understanding of science and technology and urged for an environment where people could get

acquainted with and gain understanding of scientific phenomena. He proposed an innovative kind of science museum where visitors could learn about science and technology by watching, but in addition, controlling laboratory equipment. Another emphasised aim, according to Oppenheimer, was to arouse the visitors' curiosity and to provide answers to their questions. As is well-known, his ideas led to the opening of Exploratorium in San Francisco, where visitors could explore scientific principles through interacting with hands-on exhibits. Today, 40 years after the opening of Exploratorium, the numbers of science and technology centres (STC) have grown dramatically and are now a part of a worldwide enterprise. Bradburn (1998) and Rennie and Stocklmayer (2003) contend that Oppenheimer's goals of enhanced interest and public understanding of science are still relevant and are explicit ambitions of STC network organisations, as well as of individual STCs. For example, the Canadian Science and Technology Museum states that their exhibitions serve to "foster scientific and technological literacy" and further to "increase understanding and appreciation of the role that science and technology has played and continues to play" (Donahue and Faubert, 2001, p. 25). Also, staff members express the view that a primary goal of their exhibitions is to enhance the visitors' interest in science (Davidsson and Jakobsson, in press).

The question is, however, whether visitors' interactions with hands-on exhibits, aiming to describe scientific principles, automatically generate an interest in science. A number of studies imply that creating an interest in science is a complex and multifaceted task where several different factors need to be considered. For example, Pedretti (2004) stresses the significance of how learning science socially is organised. She argues that exhibitions need to have the potential to stimulate dialogue with others and promote reflexivity about scientific phenomena in order to enhance visitors' interest in science. But what studies within the broader enterprise of science education may provide additional information, valuable for the staff members when planning new exhibitions? And what studies within this field may contribute to increase the enterprise of STCs' understanding of how their exhibitions can enhance visitors' interest and knowledge in science? One example could be the study of Häussler and Hoffman (2000) as they found that many students experienced science as uninteresting in the context of school science, but responded positively when it came to science and its practical applications, as well as to its

potential in explaining naturally occurring phenomena. A possible interpretation is that when science becomes de-contextualised and isolated from everyday life, students tend to feel unengaged in science. This interpretation can also be valid in STC settings as exhibitions have been criticised for tending to display de-contextualised science. Pedretti (2002) argues that the content of exhibitions, to a large extent, concerns "the wonders of science", where science is presented in an unproblematic and product-oriented way.

A question related to this discussion is how staff members consider what scientific content to include and how this content can be organised in their exhibitions? The purpose of this article is to investigate what scientific content staff members focus on when they plan and construct new exhibitions. It further aims to discuss these priorities in relation to the concept of scientific literacy and young people's attitudes towards science.

The scientific content of exhibitions

The debate about the content and the design of exhibitions at STCs has, for several decades, been a target for scrutiny and critique. For example, exhibitions based on curiosity cabinets and wonders of science have been criticised for only presenting science as free from societal values and ethics (e g Champagne, 1975; Bradburn, 1998; Pedretti, 2002). In order to challenge the conventional phenomenon-based installations, Pedretti (2004) argues for the inclusion of socio-scientific issues in exhibitions. She argues, in her review of visitor studies, that the relation between science and society may be addressed through issues-based exhibitions, where visitors are given opportunities to discuss and debate possibilities as well as constraints about contemporary science. But the staff members' choices of what scientific content to include in an exhibition do not simply concern putting science in general on display. Davidsson and Jakobsson (2007) argue that every exhibition is a result of conscious and unconscious choices of what aspects of science to include or exclude. Also Macdonald (1998) argues that these choices create *particular kinds of science* for the public, which pronounce certain practices and artefacts as belonging to science. These choices also implicate what science an informed public ought to know about. In a study, Davidsson and Jakobsson (2007) further explored staff members'

views of what aspects of science they chose to include in their latest exhibitions. The results revealed that the most common aspects displayed were scientific facts, science in society and science in a technical perspective. Together with the aspect of how modern science is generated, these constituted an image of the usefulness of science, which emphasises scientific benefits in our society. Meanwhile this image of science tends to exclude aspects such as controversial issues, values and other features of socio-scientific issues.

But how do visitors apprehend the scientific content of exhibitions and how do they relate this to their own ideas about science after a visit to a STC? Rennie and Williams (2002) found that most visitors experienced that they had learnt new scientific knowledge. Two thirds of the visitors also expressed recognition of a change in their relationship with science as they, after the visit, were able to exemplify how they thought differently or more deeply about science. However, the overall changes towards a more positive attitude towards science also resulted in a less scientific view. This was evident through the survey, as the respondents were more likely to think uncritically about science after their visit to the centre. In the same study the authors further compared the visitors' ideas about science to those of the staff members. Their results suggest that staff members, to a higher extent, expressed a less limited view of science than the visitors. This means that they tended to agree, to a greater extent, that scientific explanations have an element of uncertainty, that scientists often disagree with each other and that science does not always have the answers to problems.

The aim of increased scientific literacy

The relevance of the public's understanding of science has been a topic of concern over the last century. DeBoer (2000) points out that already at the beginning of the 20th century an important argument was how to enable individuals to participate more effectively in an open, democratic society. In the late 1950s, the Rockefeller Brothers Fund (1958) urged for more highly educated citizens, that understood the science enterprise, whether one was to become a scientist or not and coined the concept of *scientific literacy*. During the 1970s and 1980s DeBoer (2000) describes a change in the significance of scientific literacy towards a focus on science in its social context. By this time, also, other

arguments for studying science, other than the democratic one, were introduced by, for example, Thomas and Durant (1987). Based on this overview, Driver et al (1996) pointed out the five arguments for studying science that they found most important; the economic, the utilitarian, the democratic, the cultural and the moral argument. These arguments emphasise, to a large extent, a broad and functional understanding of science, in order to handle everyday life and are not directly aiming to prepare students for scientific careers. The significance of scientific literacy still stresses the importance of becoming an active citizen, who can take part in, for example, decision making processes. This reasoning can be seen in several descriptions of scientific literacy as for example the interpretation by Flower (2000). He argues that a science-literate individual has knowledge of scientific concepts, scientific processes and the effect of science and technology in society to a degree which allows her/him to be active in decision making processes. OECD/PISA has more explicitly defined scientific literacy as:

> *The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.* (OECD, 2003, p. 133)

The PISA study of 2006 (OECD, 2006) puts further emphasis on scientific literacy and the definition is expanded and more explicitly includes the individual's ability to identify scientific issues, to explain phenomena scientifically and to use scientific evidence in order to take an active part in a democratic society and to become a reflexive citizen. This change in definition exemplifies a general problem with the use of the concept of scientific literacy, namely, as DeBoer (2000) points out, that there exists no common agreement about a definition. There are thus diverging understandings of the meaning of scientific literacy and the concept tends to include everything. This has consequences as to whether scientific literacy may be achieved through attending scientific exhibitions or by learning specific content standards, which then are transformed into measurable outcomes of assessing visitors' or students' learning.

The aim of increased interest in science

Along with, and closely related to, the discussion about scientific literacy, is the lack of interest many young people in western countries express when it comes to choosing an education or a future career within science. Worldwide studies (e.g. the SAS-project and ROSE) indicate a trend of decreasing interest in science among students in developed countries. Sjøberg (2002) speculates whether this can be an effect of bad teaching or low public understanding. Another reason, he proposes, could be that young people hold a rather negative attitude towards certain aspects of society, of which science is one. Schreiner and Sjøberg (2007) argue that young people in late modern society feel free, to a large extent, to choose their own religious and social grouping, political affiliations, education and moral values. According to Giddens (1991), this means that the cultural liberation of the individual is no longer perceived as something that is handed out or given, but rather something one has to choose or develop oneself. However, Häussler and Hoffmann (2000) claim that the issue of the decreasing interest in science is more complex. The students in their study express negative attitudes towards physics as a school subject, but when they were asked about their interests in general, they responded positively to physics in the context of its practical applications.

What makes science interesting but school science uninteresting? Is it possible to identify what young people find interesting about science? Osborne and Collins (2001) explored students' views about the school science curriculum and what aspects they found interesting and valuable. The students thought of school science as an important subject to learn, but not for themselves. They referred to school science as a body of knowledge, characterized by its content and with an emphasis on facts. They also expressed the perception that school science is fragmented, with a lack of discussion and a lack of relevance. In order to make school science more interesting, they wanted more time for discussions related to controversial or socio-scientific issues. The students, in addition, requested challenging situations and expressed a will to understand not only what happens, but also why things happen. This reasoning is reinforced in the study by Cerini et al (2003) where the students expressed a positive attitude towards the inclusion of socio-scientific issues involving controversial, philosophical and ethical dilemmas into the science curriculum. The students argued in favour of more practical

work, as well as group discussions, in order to develop their own understanding and ideas.

When it comes to school science, Jenkins (2004) questions how long it is possible to encourage the view that the world is much simpler than it really is and promote unsustainable claims about the power of science to explain and control. Reiss (2004) refers to this narrow view of science as reductionistic and stresses the importance of teaching topics that are of concern to young people. Both Jenkins (2004) and Reiss (2004) propose a change in the science curricula, where less attention has to be given to the minutiae of established science and instead consider issues where science is less secure or controversial. Another important issue, Jenkins argues, is to acknowledge the limitations within science as it may lead to a richer understanding of the subject. Osborne (2002) argues further, that the conception of science in school risks being too narrow when emphasizing that empirical activity is central to understanding science. By excluding the importance of language, discussions and argumentation, future citizens will be ill-equipped to be critical consumers of science.

In a study of Brown (2006), the results show that students experience the genre of science discourse as a problematic component of science learning. They found it difficult, when using scientific language, to relate to themselves and their comments reflected that science was unique and only applicable in the science classroom. In order to make the nature of science explicit, but also as a crucial factor to be able to develop scientific literacy, Osborne (2002) stresses the importance of showing the students how science is a cultural activity undertaken by the medium of language. This means, he argues, to give students opportunities to read science, discuss how ideas are supported and write scientific texts. Also Fensham (2000) argues for a change in science curricula, where the conceptual content must be more selective. If there is a will to include a 'science for all', the content that is to be learnt must have future significance. However, he contends that efforts aimed at redirecting science curricula have encountered resistance from powerful groups in society. This means that a defeat at secondary levels of science courses has a knock-on effect to lower levels, because of the academic status science hold as prerequisites for applying to higher education.

The study

The discussion has so far focused on the STCs' aims of enhancing visitors' interest in science and increasing visitors' scientific literacy. Furthermore the discussion has highlighted studies about the scientific content in exhibitions at STCs. Several of these studies (e.g. Pedretti, 2002, 2004; Davidsson and Jakobsson, 2007) indicate that the scientific content risks being presented in an unproblematic and product-focused way in exhibitions. But according to Flower (2000), the concept of scientific literacy, include a broader view of science comprising not only understanding the significance of concepts, but also scientific processes and the effect of science and technology in society which allows a person to be an active citizen. Moreover, studies within the field of science education about students' attitudes towards science indicate that a fact-oriented and de-contextualised way of presenting science risks leading to a disengagement in science. But is there a risk that if STCs present science in an unproblematic, product-focused and de-contextualised way that visitors develop similar ideas about science? To be able to approach this question it is necessary to explore how staff members' consider and decide on the scientific content in exhibitions.

The aim of this study is therefore to investigate how staff members consider what scientific content to include and on what aspects of science they focus when planning an exhibition. The research question is:

- In what ways do staff members consider what scientific content and what aspects of science to include when planning a new exhibition?

Methodological considerations

This study is part of a larger project, the aim of which is to explore underlying assumptions and factors that affect the content and design of exhibitions at Nordic STCs. To be able to investigate these factors and assumptions and to answer the research question in this study empirical data has been collected successively in two different phases. Because there is a lack of studies concerning staff members' views about this issue, there was a need to obtain a general understanding and to detect patterns concerning the content and the design of exhibitions. Therefore, as the first phase, a quantitative approach was chosen and 66 staff

members from 30 different STCs participated. The questions in the questionnaire focused on to what extent the respondents believed their latest exhibitions displayed different aspects of science. From the results of this phase it was possible to discover the existence of *different images of science* in exhibitions (Davidsson and Jakobsson, 2007).

From the first phase of the data collection it was however not possible to draw any conclusions about the ways in which the different aspects of science were displayed. Therefore, as the second phase, a qualitative approach was selected. However, as the respondents were spread over a large geographical area, a personal meeting was impossible. This was circumvented by using telephone interviews. A weakness related to the choice of using interviews is that it is not possible to observe the actual items being discussed during the planning and construction of new exhibitions, but instead the respondents were asked to comment on this process (Silverman, 2006).

In the second phase the respondents were chosen through purposive sampling (Patton, 2002; Silverman, 2006) where the criterion for selection was that the respondents should be responsible for designing and creating new exhibitions at their STC. The intention was to give the respondents opportunities to reason freely and reflect upon the scientific content of their exhibitions. All the respondents were confronted with the same core questions and the interviews aimed at providing opportunities to discuss these freely, without interruptions. This was done in order to avoid the use of guiding questions and thereby increasing the reliability of the study (Kvale, 1997). In the second phase 17 staff members from 11 different STCs were interviewed for 40 to 60 minutes.

The research question in this article focuses on how staff members consider what scientific content and what aspects of science to include when planning new exhibitions. The respondents were therefore asked whether they had different opinions about what to include in their exhibitions. They were also asked how they handle these differences of opinions within the staff group. Moreover, two content aspects were chosen; scientific processes and the relation between science and society, as examples of possible aspects of science to display. These are only two possible content aspects among many other conceivable aspects. Hence, this does not mean that these are the only aspects or the most crucial aspects to include, but instead these could constitute important parts of an exhibition in order to mediate a broad understanding of science to the

visitors. The reason for choosing scientific processes and societal aspects of science as specific content aspects, derives from the previous discussions about critical issues-based exhibitions (Pedretti, 2004) and different images of science at STCs (Davidsson and Jakobsson, 2007; Macdonald, 1998). The aspect of scientific processes refers here to an ongoing activity from which scientific knowledge claims are developed. It also incorporates different explanatory models and how scientific ideas are tested and discussed in order to reach consensus (Sjøberg, 1998).

As an attempt to explain some of the results of this study, ten statements from the questionnaire, from the first phase of data collection, were considered. These statements have not previously been regarded and concern staff members' own ideas about science as an enterprise and the relation between science and society. It is of course impossible, by using ten statements about science as an enterprise and about science in society, to describe broadly the respondents' ideas about science. Instead these statements are used as indicators and to be able to describe a trend among the respondents. All statements originate from the study of Rennie and Williams (2002) where five statements, *researchers always agree with each other, scientific explanations are definite, science has solutions to all problems, researchers keep testing theories to improve them and decisions in scientific research involve ethical decisions* are to a large extent the same. The remaining five statements were inspired by the same study, but differently posed.

Analysis

The interviews were transcribed and explored without considering any predefined categories. Instead patterns were identified through a two-phase analysis (Patton, 2002). The first phase sought to discover and identify patterns, themes and relations and resulted in preliminary descriptions of what scientific content the respondents focused on when planning an exhibition. It furthermore comprised patterns which describe how the respondents express those scientific processes and how the relation between science and society are approached and presented in their latest exhibitions. The second phase of the analysis aimed at testing and verifying these patterns and also to seek explanations as to why these patterns appeared. These explanations were sought not only in the interview, but also through analysing ten statements from the survey. The

statements were analysed through descriptive statistics using mean values and standard deviation.

Results

Scientific content discussions and practical concerns

The staff members in this study were given opportunities to discuss the scientific content and different aspects of science and to reflect upon both what was chosen to be included in the exhibition, and also on what was excluded. The analysis revealed that the focus of most of the respondents' reflections was, to a low degree, related to the scientific content of the exhibitions. Instead their reasoning, to a large extent, concerned problems of practical and organisational character. For example, this meant, according to the staff members that priorities were made because of what was practically possible to achieve, using accessible material to create an exhibit, because of limited exhibition area or whether the exhibit was seen to be enjoyable. In Excerpt 1 Anne discusses an exhibition that aims to focus on the function and the design of telephones and she reflects upon the different opinions there were among the staff members, concerning the scientific content.

Excerpt 1

1	I	Have you had different opinions concerning *what* to present?
2	Anne	Oh, yes!
3	I	Could you give me an example?
4	Anne	Among other things, to get the content to correspond to the design… that was a problem
5	I	Yes, were there also problems related to the scientific content?
6	Anne	The problem… what it should contain, was in itself not the problem, rather it was to synchronize it with the design.
7	I	Okay
8	Anne	To… to have such an outline where what you want to display become really clear.

9	I	Okay, and were there different opinions about how to do this?
10	Anne	Yes
11	I	What opinions were represented?
12	Anne	Yes, it was… on the one hand it was… yes, partly it was the content… that it should, so to say, be shown in a certain way according to me, but then it was the esthetical. It always involves clashes [inaudible] aspects that the designer… that it should be in a certain way because it is nicer, right…
13	I	Yes…
14	Anne	…and then I said that you can't have it that way because you can't have a group of students here. They can't get through. There is not enough space. Such things.
15	I	Yes…
16	Anne	And you can't display it that way because, yes for example, this is a process…
17	I	mm…
18	Anne	Meanwhile, I don't know, it is hard to say if we will get hold of that object and because of that, you want a flexible system… objects may arrive at the last moment and then we want to show them
19	I	mm…
20	Anne	…and therefore it is necessary to have a flexible system.

When Anne is asked about different opinions about *what* to display she refers to the difficulty in *how* to present the content (4). She is asked again about the scientific content and she explicitly says that it is not the scientific content in itself that is the problem, but instead how to synchronize it and the design (6). According to Anne, the disagreement among the staff members seems to concern esthetical matters (12) but also organisational matters, such as whether there is enough space for a school class (14). Anne exemplifies yet another organisational issue in the benefit of having a flexible system which allows the staff to move the objects, depending on what objects they have access to (16, 18, 20).

Anne's reasoning throughout this excerpt constitutes an example of what most respondents express when discussing what choices they make

concerning the scientific content. The major problem does not seem to be how to prioritize what aspects of science to display, but instead there is an emphasis on problems related to how to organize it. It is obvious throughout the data material that there exist a lot of practical concerns that need to be solved in order to present a new exhibition. However, from the analysis it is not possible to explain the underlying causes as to why the scientific content does not seem to be discussed to a higher extent. One possible explanation could be that the staff members need to solve practical issues, which means that there is not enough time to discuss questions related to different aspects of science. Another reason could be that the staff members actually do not see the choice of the scientific content as an important issue. The second explanation is highlighted in Excerpt 2, where John discusses choices concerning the content of a sport exhibition.

Excerpt 2

1	I	Yes, how do you handle different opinions about the scientific content?
2	John	Yes, well… then we consult the expert group… the content is actually not of any concern.
3	I	No…
4	John	I believe, right now we constructing one [exhibition] about sports and then you could have some discussions about how much to include from science and how much of athletes who talk and tell…
5	I	mm…
6	John	Such discussions could come up
7	I	mm…
8	John	What we want to focus and what is the core. There we could have different opinions, but we usually conclude… this group works very creatively and well.

If there is any disagreement among the staff members about the scientific content, John argues that they consult the expert group. However, he says that *the content is actually not of any concern* (2). Instead he discusses to what extent the exhibition should be built upon scientific knowledge and to what extent it should be represented by sportsmen and stories from the world of sports (4). He clarifies that they

seek a focus in their exhibition and these kinds of discussions with different opinions occur (8).

When John refers to the expert group, it is not explicit whether this group is asked about the ambiguity of a certain topic or the latest research, about what content or aspects of science to include in the exhibitions or other issues of concern. A possible interpretation is that John understands the question about the scientific content, as when different understandings exist within the staff group about a scientific phenomenon, they consult the expert group to get a correct answer. From this reasoning it seems that John refers to the body of scientific knowledge as an entity which gives correct answers. In relation to the statement about the focus of the exhibition, he seems to view science and the world of sports as two different sources or bodies of knowledge which could be used in order to constitute this exhibition. The discussion is not about specific scientific foci or about what aspects of science should be included in the exhibition but *how much to include from science and how much of athletes*.

Science in society and scientific processes in the exhibitions

In order to explore how the staff members relate to and consider the scientific content and different aspects of science, they were confronted with questions about how science in society and how scientific processes are approached, in their latest exhibitions. The respondent were therefore asked in what ways visitors may experience that science is affected by society, politics or economy. A majority of the respondents express the opinion that this aspect is considered and that it is represented in their exhibitions in different ways. Three of the respondents argue more explicitly that this aspect is not evident to the visitors. However, most of the respondents give examples where the relation between science and society seem to be implicit. For example, one respondent states that since overweight and fatness is a societal problem this relation is emphasised in her exhibition. Another example, posed by several of the respondents, is that it becomes visible to the visitors that science is affected by society, politics and economy since their STC cooperate with local companies. A possible interpretation of this statement is that the staff members experience that the local companies represented in their exhibitions, use scientific or technological knowledge, which clarifies the relation

between science and society. A few respondents describe how science is affected by society, politics or economy more carefully. However, there seems to be a risk that this relation is evident to those staff members, but tend to become implicit to the visitors. In the following excerpt (Excerpt 3) Jack is asked how visitors may understand that science is affected by society, politics and economy in his exhibition.

Excerpt 3

1	Jack	I mean fuel cells again
2	I	Yes…
3	Jack	is something we all know and much research is conducted and not least oil companies spend enormous amounts of money to produce fuel cells
4	I	Mm…
5	Jack	That is you see a direct politically and economically motivated research, right…
6	I	Yes, right… Do you believe you emphasised that?
7	Jack	Yes
8	I	Yes…
9	Jack	Well, that is to say it was not written clearly, but somewhere it was visible. As if this is the front line.
10	I	Yes, right
11	Jack	We had pictures of, of buses using biofuel, that is… one emphasised that there is a border… very clearly I believed in the whole exhibition was that we are in a borderland, a transition from a society based on fossil fuels to something else. That is we emphasised the alternatives…

Jack reasons that fuel cells are an example of the relation between science and society, politics and economy. He clearly expresses this connection and relates it to the *enormous amounts of money* spent on research, both within the research community as well as at oil companies (3). He reinforces this view by stating that the research is politically and economically motivated (5) and that this is emphasised in his exhibition (7). However when he reflects on this again he hesitates and says that it is perhaps not clear to the visitors (9). But he then reclaims that this aspect was emphasised *in the whole exhibition, that we are in a borderland from*

a society based on fossil fuels to something else. He also contends that the exhibition emphasised the alternatives to fossil fuels.

Jack emphasises that his exhibition describes the development of a fossil fuel based society towards a society based on alternative fuels. He also claims that this future development is explicit to the visitors. In this perspective the relation between science and society, economy and politics is distinct to the visitors. Jack also reasons in what ways this aspect affects today's fossil based society and the development towards an alternative society. However he expresses uncertainty concerning whether this influence is evident to the visitors when stating that *it was not written clearly, but somewhere it was visible* (9). In this perspective the relation between science and society seems more implicit to the visitors.

The staff members were furthermore asked in what ways the visitors can recognize scientific processes and how the scientific community has reached consensus. The analysis reveals that 13 of the 17 respondents state that this aspect is absent or implicit to the visitors in their exhibitions. This means that in a majority of the exhibitions the aspects of scientific processes and how the scientific community has reached consensus are consciously or unconsciously excluded. However four respondents argue that they display scientific processes in their exhibitions and give concrete examples of this. Three of the staff members refer to the fact that they display the history of science in order to explain science as an ongoing activity and how the scientific community has reached consensus. The fourth respondent refers in Excerpt 4 to contemporary science and reasons for an exhibition concerning the climate and how different models of explanation to global warming were illustrated in order to display ongoing scientific processes and consensus.

Excerpt 4

1	I	Is it possible to recognize, in the exhibition, how the scientific community has reached consensus, how we have come to know what we know today?
2	Jacob	When it comes to the researchers' points of view… and that is a little bit controversial since there are clashes of opinions between geologists and meteorologists in how you regard climate changes. But there we have chosen to

		video record interviews of different experts and then cut different quotations.
3	I	Okay
4	Jacob	And there I guess you could see some differences between different experts.

Jacob exemplifies how scientific processes could be represented in an exhibition about climate changes through giving voice to different researcher's opinions using recorded interviews (2). He argues that this is a controversial matter since the researchers have different opinions concerning what models of explanation to use when discussing global warming. However he seems to be uncertain whether this exhibit actually makes different models of explanation obvious to the visitors when claiming, *I guess you could see some differences between different experts* (4).

This exhibit seems to constitute an exception in the data material, as the staff members here actively chose to display different views among researchers, as geologists and meteorologists use different models of explanation. In that way this exhibit could represent an example of ongoing processes of how the scientific community gradually reaches consensus. But, when referring to Jacob's statements a possible interpretation is that these kinds of exhibits are not common as it seems to be controversial in exhibition contexts to display different opinions among researchers and experts. This interpretation is reinforced as several examples exist in the data material where the respondents discuss why they believe that aspects, such as scientific processes, are likely to be declined in exhibitions. These examples seem to express an anxiety among staff members in displaying aspects of science which the visitors may experience as unclear or ambiguous. In another exhibition about global warming, Sophie discusses the lack of different models of explanations and continues in Excerpt 5 to explain why different models of explanation tend to be absent.

Excerpt 5

1	I	In general, do you believe you avoid displaying two different models of explanations?
2	Sophie	Yes, well I believe so… because this educational… one… I think that in this world, the teacher world… actually,

		because we are much more influenced in our museum…
3	I	mm…
4	Sophie	…by school, as I see it anyway…
5	I	Yes…
6	Sophie	… and in school you have traditionally always avoided having loss of words
7	I	mm…
8	Sophie	…and you would rather give an answer. If you provide answers like on the one hand this but on the other that it becomes confusing. And then this aspect matters, that people move quickly in an exhibition they look…quick, quick… and then you don't want to be shilly-shallying but rather being… There have been, for example… I don't know whether the sign is still there, but how can an aircraft fly…
9	I	mm…
10	Sophie	…and there are a couple explanations to that and then I think that both of them were presented, but it was through such a "know more"-text and it was I guess not the first thing you encountered […]
11	I	But one rather wants to provide a correct answer?
12	Sophie	Yes, I believe you want to and meanwhile this is quite unscientific…
13	I	mm….
14	Sophie	… an unscientific way because in science it isn't… always the answer that is the main thing but rather a search…

Sophie ponders about several explanations as to why different models of explanation in general are likely to be avoided in exhibitions. She argues that school has a strong influence on the museum (2, 4). According to her, school traditionally has *avoided having loss of words* (6) but rather strives to provide an answer (8). Sophie argues that it becomes confusing to visitors if they are confronted with differing answers which are valid in different contexts. Further on, she contends that visitors move quickly through the exhibition and because of this *you don't want to be shilly-shallying* (8). She gives an example of an exhibit about what makes an aircraft fly, where different models of explanation

are presented through a "know more-text". However, she seems to be uncertain as to whether the visitors actually encountered these explanatory models (10). Finally she questions the strategy of only providing the correct answer and argues that it is quite an unscientific approach (12). Instead she emphasises that *it isn't always the answer that is the main thing but rather a search* (14).

In this excerpt, Sophie discusses several explanations as to why different explanatory models are poorly represented in exhibitions. First she mentions the school tradition which she claims affects the exhibitions by avoiding exhibits with incomplete explanations. Further on she expresses concern of the risk of confusing visitors when they not provide certain and correct answers. This reasoning is also found among several other respondents and some, in addition, argue that providing different explanatory models, or ambiguous answers may undermine the credibility of their institutions.

The respondents' views of science as an enterprise

A general conclusion from the results so far is that the scientific content in the respondents' latest exhibitions seems, to a low extent, to integrate the aspects of scientific processes and the relation between science and society. In Excerpt 5, Sophie discusses different explanations as to why these aspects tend to be overlooked. But could a supplementary explanation be that the staff members' own views of science, as an ongoing activity and about how ideas are tested in order to reach consensus, affect the scientific content in exhibitions? Is there a risk that scientific processes and the relation between science and society is overlooked when constructing new exhibitions because the staff members do not allow for these aspects when referring to what science may be?

The results of the questionnaire, which sought indications of the respondents' views of science as an enterprise and the relation between science and society, do not support such reasoning. The respondents were asked to consider to what extent they agreed with different statements about science on a seven grade scale. The first four statements concern consensus among scientists and fallibility of scientific knowledge and the mean values of these statements can be seen in table 1. The first statement, *scientists always agree with each other* (1), got the lowest mean value, which means that the respondents agreed with this only to a

limited extent. The statements, *scientific explanations are definite* (2), *science has solutions of all problems* (3) and *researchers keep testing theories to improve them* (4) aimed to explore the staff members' views of the fallibility of scientific knowledge. Statements (2) and (3) got low mean values which means that the respondents agreed with these statements to a low degree. The third statement got a high mean value which means that the respondents agreed strongly with this view. The mean values of these four statements indicates that the respondents in general have a broad understanding of consensus among scientists (1) and the fallibility of scientific knowledge (2-4).

Table 1. The mean values showing to what extent the respondents agree with statements about science as an enterprise (very low extent [1] – very high extent [7]).

	Statement	**Mean**	**Std**
1	Researchers always agree with each other	1.50	1.20
2	Scientific explanations are definite	2.12	1.40
3	Science has solutions of all problems	2.19	1.48
4	Researchers keep testing theories to improve them	5.35	1.45

The following statements in the questionnaire considered the relation between science and society and aimed at focusing human aspects of science. The results can be seen in table 2. The statement *science is free from values* (5) got the lowest mean value, which means that the respondents, to a low extent, agreed with this statement. *Science is impersonal* (6) got a mean value close to the centre of the scale and the standard deviation indicates that their answers are spread. Further on, *decisions in scientific research involve ethical considerations* (7) has a mean value which is above the centre of the scale. This indicates that the respondents tended, to a higher extent, to agree with this statement. Most of the respondents agreed to a high extent that *science is a part of our culture* (8). The results from these statements indicate that the respondents to a high extent regard values and ethical considerations as a part of science and that science is embedded in our culture.

The two final statements concern to what extent the respondent express that *all people need to know how new scientific knowledge is generated* (9) but also, to what extent *all people need knowledge about*

scientific concepts and phenomena (10). Statement (10) got a very high mean value and low standard deviation, which means that the respondents strongly held this view. When it comes to the statement that *all people need knowledge about how new scientific knowledge is generated,* this also got a high mean value, but the respondents' answers are more spread. From this results it seems that the respondents tend to consider scientific knowledge about concepts and phenomena more important to know about than knowledge of how new scientific knowledge is generated.

Table 2. The mean values showing to what extent the respondents agree with different statements about science (very low extent [1] – very high extent [7]).

	Statement	**Mean**	**Std**
5	Science is free from values.	2.03	1.48
6	Science is impersonal.	2.91	1.64
7	Decisions in scientific research involve ethical considerations.	4.82	1.90
8	Science is a part of our culture	6.44	0.96
9	All people need knowledge about how new scientific knowledge is generated.	5.42	1.38
10	All people need knowledge about scientific concepts and phenomena.	6.61	0.69

From these results, it is difficult to describe an unambiguous image of the respondents' views of science as an enterprise and the relation between science and society. However, it can be seen that answers to statements one to eight provide indications that the staff members recount for tentativeness concerning what is considered as scientific consensus as well as societal and human aspects of science. These results are well in line with the study of Rennie and Williams (2002) as they conclude that the staff members in their study generally hold a broad view of the nature of science.

Discussion

The principal aim of this study was to explore what scientific content

and on what aspects of science staff members focus when planning a new exhibition. The results suggest that there is an obvious tendency to discuss the scientific content in terms of organisational matters. For example, the respondents focused on what was possible to implement in limited exhibition areas, whether the exhibit was considered to be enjoyable or what material was available for exhibit constructions. Some of the respondents, in addition, state that the relation between the scientific content and what different aspects of science to display actually is unproblematic. However, it is not possible to conclude whether these results may be explained by the fact that they actually choose to disregard the possibility of discussing the scientific content and different aspects, if this is due to practical circumstances or if the staff members do discuss these issues but do not recall this in the interviews.

When the staff members were asked to consider the relation between science and society, politics and economy the majority argued that these aspects were represented in their exhibitions. However, most of the respondents tended to give implicit examples, such as this relation being obvious to visitors, because overweight and fatness is a societal problem or that the cooperation between the STC and local companies highlights this relation. When it comes to scientific processes a majority of the staff members argue that this aspect is absent or implicit to the visitors in their exhibitions. These results are in line with the conclusions of Davidsson and Jakobsson (2007). They found that the most common image displayed at Nordic STCs, *the usefulness of science,* stresses applications of science in our society and excludes aspects such as scientific processes and controversial issues. Exhibitions that only a few aspects risk, according to MacDonald (1998) and Pedretti (2002), displaying science in a too narrow and single-dimensioned way. This could mean that these kinds of exhibitions risk losing important aspects, which may contribute to enhance the visitors' understanding of science as an enterprise. This reasoning could provide a possible explanation as to why the visitors, in the study of Rennie and Williams (2002), were more likely to think uncritically about science after their visit to a STC.

Another aim of the article was to discuss staff members' priorities about the scientific content in exhibitions in relation to young people's attitudes towards science and the concept of scientific literacy. STC, to a large extent, turn to young people, both when attending exhibitions in family groups or together with their class. School groups make up a

significant part of visitors at STCs. According to ASTC (2006) about 20% of the total on-site attendance during 2006 was made up of students in school groups and more than 80% of off-site attendance. But how can these results, described in this article, be related to the ongoing research and debate within the science education enterprise about what influences students' attitudes towards science? And what consequences does this have for the STC movement's aim of enhancing young people's interest in science?

In order to make school science more interesting, the students in the study of Osborne and Collins (2001) express the view that they want more time for discussion during science lessons. The students, in addition, urged for time to explore and relate science to different societal aspects, such as controversial issues, philosophy and ethics. Also within the science education enterprise, several scholars (e.g. Osborne, 2002; Fensham, 2000) emphasise the importance of discussions where the language is used for negotiation and argumentation to be able to test, verify and refute scientific evidence. Osborne (2002) argues that this is crucial in order to become a critical consumer of science.

When it comes to exhibition contexts, these offer possibilities for discussion. The results of several studies contend that exhibitions engage visitors in discussion with their peers or families. For example Allen (2002) concludes that visitors are engaged in *learning talk* for more than 80% of the time spent in the exhibition. Another example is the study by Tunnicliffe (2000) who investigated the content of children's talk when visiting an exhibition about dinosaurs. She found that the student groups tended to focus on the salient body features of different dinosaurs. But what possible discussions do the contexts of different exhibitions offer? The results of this study suggest that aspects such as the relation between science and society, politics and economy, as well as scientific processes, tend to be implicit to the visitors or seem to be represented to a limited extent. The staff members are thus likely to consciously avoid different explanatory models and they express an uncertainty in displaying different reasoning or argumentations which are valid in different situations. Several respondents argue that displaying different researchers' points of view, or providing ambiguous answers, risks questioning the credibility of their museums. This risks bringing consequences when it comes to the content of the visitors' conversations. According to Allen (2002) and Tunnicliffe (2000), exhibitions offer

possibilities for discussions, but there seems to be a discrepancy between what the discussions concern (e.g. body features) and what young people express they would like to discuss (e.g. socio-scientific issues, philosophical issues). From this reasoning, there is thus a risk that the aim of increased interest in science is left unfulfilled when exhibitions not provide opportunities for young people to discuss science in relation to different societal aspects.

Another aim posed by the enterprise of STC is an increased scientific literacy among citizens. As seen previously there exist several different definitions within the science education enterprise as to what a scientifically literate person needs to know, but a focus is to acquire knowledge in order to be an active citizen in decision making processes. This involves for example learning about scientific concepts, scientific processes, being able to identify scientific reasoning and being a reflexive citizen (Flower, 2000; OECD, 2003; OECD, 2006). But in what ways may exhibitions at STCs contribute to increased scientific literacy? The results of this study indicate that the staff members are aware of and have a broad understanding of science when it comes to the nature of science, scientific processes and consensus. This is also evident in the study of Rennie and Williams (2002). The results imply that the staff members actually choose not to display certain aspects as they instead express a will to provide correct answers and to avoid confusing visitors. From this reasoning it is possible to assume that the staff members tend to make themselves guardians with respect to the visitors. This means that there is a risk that these aspects of science seem consciously be excluded in exhibitions. Does this mean that science and technology centres, through their eagerness of enhancing visitors' scientific literacy, instead contribute to create detachment or unconcern about scientific issues?

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III

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RESEARCH REPORT

Staff Members' Ideas about Visitors' Learning at Science and Technology Centres

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This study investigates staff members' ideas and assumptions about visitors' learning at science and technology centres. It also aims to explore in what ways their reasoning intersect with existing theories about learning within the field of science and technology centre research. The results of the study reveal that the staff members allude to learning processes differently by distinguishing organized from non-organized learning, theoretical learning from practical hands-on learning, and serious from non-serious learning. According to most of the staff members, these also conclude with different learning outcomes. Further, a majority of the staff members state that they do not have any scientific knowledge about learning despite the fact that they work with the construction of new exhibitions. When discussing visitors' learning, the staff members instead refer to personal experiences, professional experiences, professional education, and external references. When it comes to how they reason about the natural scientific content, nearly all express that they use references from the natural science community and researchers' knowledge. The article moreover discusses in what ways a socio-cultural approach may be used in order to understand how learning arises when visitors interact with exhibits.

Introduction

Only few studies investigate underlying assumptions of how exhibitions are planned and created at museums and at science and technology centres (STCs). One example is Knutson's (2002) research about the development of a temporary art and science exhibition. She found that staff members, depending on their educational background and professional role in the design team, had different notions about what the visitors should experience. Also, Macdonald (1998) studied the construction of a science exhibition and found that assumptions, rationales and compromises

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that lead to the finished exhibition were not explicit to the visitors. In particular, the relation between science and the societal and the political contexts tended to be overlooked as the staff members concentrated on practical and aesthetic matters of the task. She argues that this can lead the visitors to experience the content of the exhibition as ready-made statements rather than as descriptions of outcomes from scientific processes.

Staff members' different agendas and their apprehensions about societal and political contexts are thus two underlying assumptions that influence how exhibitions are constituted. But what assumptions about visitors' learning do staff members express, and what consequences follow these when planning and constructing an exhibition? The purpose of this article is to investigate staff members' ideas about visitors' learning in relation to their exhibitions and to explore how their reasoning intersect with and are related to existing theories about learning within the field of STC research. Furthermore, it aims to study what references of knowledge staff members refer to when reasoning about visitors' learning and when reasoning about the scientific content.

Theoretical Background

Approaches to Learning in Science and Technology Centre Research

A considerable and dominating part of the research within the field of STCs is studies concerning visitors' learning outcomes. What do visitors actually learn, understand, or apprehend when visiting an exhibition? One example of these kinds of studies is that by Bishop and Reed (2005) where students participated in a course located at a STC. The study concludes that students, through being engaged in activities at the centre, developed an enhanced knowledge about the science content. Schauble, Leinhardt, and Martin (1997) argue that a problem with these kinds of studies is that the correlations between learning outcomes and the visit are not clear enough. It is hence not possible to assert that the learning outcomes are only related to the visit. An attempt to attend to this problem has been to conduct pre-tests and post-tests. One example is the study of Heard, Dival, and Johnson (2000) where students, after a questionnaire pre-test about scientific facts and concepts, interacted with exhibits at a STC. The post-test concludes that the students achieved higher scores on the same questionnaire. Some evident shortcomings with such an approach are that the learning outcomes are not taken into consideration and discussed. This means that learning risks being seen only as an ability to render or reproduce non-contextual scientific facts and concepts. Another problem, according to Falk and Dierking (2000), is that these studies are not related to a theoretical framework for learning at STCs and do not have as their purpose the development of such a framework. Consequently, this dominating paradigm has been criticized (Anderson, Lucas, & Ginns, 2003; Schauble et al., 1997) for having weak or even a lack of theoretical frameworks, where learning is implicit and undefined. Paris and Ash (2000) and Schauble et al. (1997) argue that this shortcoming limits the

possibility of making generalizations and comparisons with learning in similar settings. Another obvious problem is that this lack of a theoretical perspective of how visitors' learning is developed risks making learning implicit and invisible when staff members plan new exhibitions at STCs.

Theoretical Models of Learning in the Context of STCs

However, different scholars have had as their intention the development of theoretical frameworks in order to describe crucial factors involved in the visitors' learning at STCs. A common assumption in these frameworks is the importance of the visitors' prior knowledge and experiences. For example, Anderson et al. (2003) relate to the constructivist perspective when emphasizing the learners' prior understanding of concepts that differentiate from scientific models of explanations. They argue that scientific ideas or misconceptions held by the individual are a result of previous personal experiences, observations of objects and events, culture, language, and teachers' explanations. To be able to discern how visitors' understanding of scientific concepts is developed, it is necessary to consider the visitors' previous experiences. Stocklmayer and Gilbert (2002) also emphasize that knowledge of the mental models visitors hold before their arrival is necessary in order to understand learning outcomes. They suggest a framework that intends to produce an understanding of scientific models called PAST (personal awareness of science and technology). This framework deals with the individual's learning from interactive exhibits as increased awareness of science and technology. They argue that their framework can probe visitors' experiences *beyond mere behavioural observations*. According to this framework, an exhibit creates a link of remembrance between earlier awareness and present experiences, which results in a new level of personal awareness. Further encounters with the same concept or phenomenon will lead to a stronger linkage and result in an even more refined personal awareness. To change the individual's personal awareness of science and technology, exhibits must be personally engaging, evoke powerful recall of current understanding, and demonstrate an evident relationship with a concept or a phenomenon. The core in this reasoning derives from Ausubel's (1978) Meaningful Reception Learning and Hewson's (1981) Theory of Conceptual Change. A problem in these kinds of framework, according to Wertsch (2002) and Säljö (2005), is that learning risks being considered only as an intramental and individual phenomenon without regarding those cultural and social situations where learning occurs.

In The Contextual Model proposed by Falk and Dierking (2000), an individual's prior knowledge is crucial in order to understand visitors' learning at museums and STCs. However, their model also includes that the visitors' physical and sociocultural context affects their learning outcomes. The physical context deals with exhibit design, advance organizers, and orientation, as well as reinforcing events and experiences outside the museum. This means that exhibition design and the surroundings need to be organized in ways where visitors are attracted to the exhibits, feel secure, and are given opportunities to focus on the exhibition content.

The socio-cultural context mainly highlights human mediation within a group and mediation by others like curators. According to Falk and Dierking, this means that museums create unique milieus for social groups to utilize each other for sharing information and reinforcing joint beliefs and for collaborative meaning-making. The model is used in a study by Falk and Storksdieck (2005) designed to find out what factors individually contribute to learning outcomes. The data consisted of pre and post interviews of more than 200 adult visitors. The results of the study show that all of the factors in the contextual model influenced learning outcomes. It was, however, not possible to discern any single factor that better than others could explain learning outcomes across all visitors.

In order to further enhance the understanding of visitors' learning, recent studies have to a higher extent focused on a socio-cultural approach. Above all, this perspective has been used in order to develop methods for collecting data or as an analytic tool to be able to study the interactions between visitors as well as between curators and visitors. For example, Allen (2002) analyses learning not from an individual, but from a group perspective, and views learning as meaning-making processes that emerge when visitors interact with each other. She argues that using visitors' talk as a methodology in research offers a rich description of what the visitors really do and talk about. In addition, this approach may be used to identify to what extent an exhibit facilitate or prevent visitors' conversations and interactions, and from that suggest changes in exhibit design. In the study Allen recorded visitors' conversations and found that more than 80% of the talk could be referred to as *learning talk*, which she defines as perceptive, conceptual, connecting, strategic, and affective talk. Schauble et al. (2002) also refer to a socio-cultural perspective when emphasizing that social interaction and cultural tools are crucial in order to appropriate knowledge, values, and expressions. Through interviews they studied staff members' understanding of children's learning when playing with exhibits. They found that the respondents, who worked as pilots, often felt puzzled about how to help the children to enhanced learning. Neither did they feel confident in identifying children's learning and when and where learning takes place. The staff members in addition framed the task of adults as negotiating a balance between play and learning, and by that differentiated play from learning. The question, however, is in what ways a socio-cultural perspective differs from other theories about learning and development and how it affects our understanding of visitors' learning at STCs?

A Socio-cultural Approach to Learning

A socio-cultural approach to learning derives originally from the cultural–historical framework of Lev Vygotsky (1929, 1978, 1986, 1987) developed nearly 100 years ago. A central idea in this theory is that the learning processes and our thinking originate from the social and cultural interaction we are exposed to everyday through encounters with others and our environment. Vygotsky argued that thoughts and higher mental functions are created and developed depending on what mediated tools and signs we use or have access to in this interaction.

Wertsch (1991) argues that mainly three themes exist in Vygotsky's theory; the genetic or developmental analysis, the claim that higher mental functioning in the individual derives from social life, and that human action is mediated by tools and signs. He defines (Wertsch, 1991, p. 28) *tools* as technical means (e.g., computers, graph calculators) and artefacts (e.g., books, cultural products) that exist in our surroundings mediating and affecting what and how we think. *Signs* are defined as psychological tools (e.g., language, symbols, formulae) that are used as means of thinking. In this way, scientific languages and scientific concepts constitute tools that we can use to formulate our thoughts about the world. Wertsch describes how our thoughts are mediated by means of tools and signs through stating that 'the mind goes beyond the skin' (1991, p. 33). This could be restated as the fact that there exists a dialectic relationship between thought and tool. Thoughts are mediated and influenced by human and cultural products embedded in the tool. Simultaneously, as we increase our understanding of how the tool may be used, our thoughts are driven and develop our learning.

However, mediation cannot be taken for granted, nor is it automatic. Kozulin (2003) argues that mediation must be grounded in *mediation of meaning* since psychological tools derive their meaning only from the cultural conventions that engender them. This means that in order to facilitate the appropriation of new psychological tools, the situation needs to focus on processes and metacognitive awareness about the tools rather than only focus on certain content. Wertsch (1991, 1998) argues that mediated action is strongly connected to mediational means. This implies that our actions above all are created and shaped depending on what kind of mediation we experience and what mediational means we use. He claims that the relationship between the action and the mediational means is that fundamental that you should talk about *individual(s)-acting-with-mediational-means* (Wertsch, 1991, p. 12) rather than only about discussing individuals' acting.

The Study

Until now we have only approached visitors' learning from a theoretical perspective and from the point of view of the current debate within the research community. But in what ways do staff members at STCs approach visitors' learning? What ideas and assumptions about visitors' learning do staff members express when discussing visitors' interaction with exhibits? And in what ways do these ideas and assumptions affect how the staff members reason about the content and the design of an exhibition? The research questions in this study are:

- How do staff members reason about visitors' learning when interacting with exhibits at STCs?
- How do staff members' reasoning intersect with and relate to existing theories about learning within the field of STC research?
- What references of knowledge do staff members refer to when reasoning about visitors' learning and the natural science content?

Methodological Considerations

This study is the second part of a larger project whose aim is to explore the assumptions and factors that affect how science in exhibitions is constituted at Nordic STCs. The first article focused different aspects of science that are displayed and in what ways these aspects constitute different images of science (Davidsson & Jakobsson, 2007). That article is based on a questionnaire in which the staff members from 30 Nordic STCs considered the extent to which they displayed different aspects of science in their latest exhibition. The results revealed that exhibitions today to a large extent display the wonders of science, presenting science in a product-oriented and unproblematic way.

The reason for choosing a questionnaire was to obtain a general view of different aspects of science as well as to attend to the lack of studies in this area. In this questionnaire a set of questions also concerned visitors' learning. However, they proved to be useless when it came to analysing staff members' views of visitors' learning. To come close to answering this question seems to demand other methodological considerations. The intention was rather to explore the staff members' reasoning and how they talk about learning and visitors' interaction with exhibits. The possible respondents were spread over a large geographical area in the Nordic countries, which meant that a personal meeting at each STC was not possible. This problem was circumvented using telephone interviews as a means to approach issues about learning. A weakness related to the choice of using interviews is that it is not possible to explore the staff members' reasoning about learning in action, but instead the respondents were asked to comment on this process. The respondents were selected for the study through purposive sampling (Silverman, 2001; Patton, 2002). The criterion for selection was that the respondents should be responsible for designing and creating new exhibitions at their STC. The purpose of this selection was to create possibilities to study the ways in which staff members' understandings of learning are represented during the planning and constructing of new exhibitions. In all, 17 staff members from 11 different STCs were interviewed for 40–60 min. The interview was semi-structured and consisted of a set of open-ended questions. In order to increase the prerequisites that the respondents would understand the questions in the same way, a pre-test and evaluation of the questions was conducted. All the respondents were confronted with the same core questions and were given an opportunity to freely reason without interruptions from the interviewer. This was done in order to avoid guiding questions and to increase the reliability of the study (Kvale, 1997). The design of the study also made it possible for the interviewer to ask follow-up questions in order to broaden the understanding of unexpected issues. This reinforced the explorative character of this study.

The research questions focused on the respondents' ideas and assumptions about visitors' learning. They were therefore asked about their understanding of 'how learning arises when visitors interact with exhibits'. This question derives from the previous discussion about different models concerning learning at STCs and intends to shed light on the ongoing debate in the field. The research questions also aim to

explore what references of knowledge the staff members refer to when reasoning about visitors' learning and the scientific content. The respondents were therefore asked 'from where do you acquire knowledge about visitors' learning'. They were also asked 'from where do you acquire knowledge about the scientific content'. The intention with these questions was to further deepen the understanding of the respondents' reasoning and also to relate this to their approach to other scientific areas such as natural science.

Analysis

The transcribed interviews were explored without existing pre-defined categories into which to fit the data. Instead the categories emerged through a two-phase analysis (Patton, 2002). The first phase involved discovering and identifying patterns, themes, and relations, and resulted in preliminary descriptions of different apprehensions of learning expressed by the respondents. This primary stage revealed a pattern where the respondents seemed to focus on learning in relation to different learning contexts. This means that the respondents related to visitors' learning differently depending on:

- under what circumstances the visit was conducted, and
- the expected learning outcomes.

These two main categories constituted starting points for further analysis in the second phase and were used to successively specify subcategories, which described different circumstances and learning outcomes. The subcategories that emerged, concerning different circumstances, were described as contrasting pairs such as organized–non-organized learning, serious–non-serious learning, and hands-on practical–theoretical learning. When it comes to the expected learning outcomes, the analysis revealed a discrepancy between creating an interest in science and learning science.

In the first phase, the respondents' different references of knowledge about learning were also recognized. The respondents' reasoning enlightened different relations between their personal ideas about visitors' learning and different scientific models of learning. These different references seemed to emphasize:

- personal experiences;
- professional experiences;
- professional education;
- external sources; and
- scientific sources.

These categories were used as an analytic tool to categorize the respondents' reasoning through the second phase. The second phase of the analysis sought to test, verify, and confirm the recognized categories. These categories were also used to analyse what references of knowledge the respondents referred to concerning the scientific content.

In order to increase the reliability of the study, the data were first analysed by two independent coders, and the results of these analysis were then compared. When there were different interpretations, the data material was reanalysed and the categories were successively modified in order to reach a final description.

Results

Since one aim of this study is to focus on how staff members reason about learning, the respondents were asked to reflect on how they believe learning arises when visitors interact with their exhibits. The analysis revealed that most of the respondents express that learning processes differ depending on whether learning arises in formal or informal contexts. Some respondents also make distinctions between practical, hands-on learning, and theoretical learning and between serious or non-serious learning. The last distinction refers to comments about that learning occurs differently depending on whether the visitors take the visit seriously or are just playing. Excerpt 1 highlights yet another discrepancy: that the learning processes differ depending on whether or not learning activities are organized.

Excerpt 1

Interviewer:	How do you think learning arises when visitors interact with your exhibits?
Carl:	Yes… 'hehe' [laugh]… it is very random depending on the reason they are here…
Interviewer:	Mm.
Carl:	… are they here together with their class or with some organized education-thing, this is one thing … Then they might be controlled by learning material.
Interviewer:	Yes, right.
Carl:	… and other things, but if you are here as a visitor who walks around on a Saturday, Sunday then you react in a completely [emphasised] different way.
Interviewer:	Yes.
Carl:	Then you walk randomly back and forth in the exhibition. You catch something and then you go there … You don't go … in a marked pedagogical track.
Interviewer:	No, right.
Carl:	And there I usually compare to how I am … so to say … when I visit an exhibition … I don't start with A and finish with Z so to speak.
Interviewer:	No.
Carl:	But I walk inside. And this looks fun, so I go there.
Interviewer:	Hmm, yes.
Carl:	So, one should not have blind faith in this pedagogy … the way that it is to be a systematically constructed thing. People, people who go there in leisure hours for entertainment, they don't act that way. On the other hand school classes and everything … that is, that is why you build exhibitions after some form of …
Interviewer:	Exhibitions turn to.
Carl:	… pedagogical ideas so that you learn from the one to the other. This also means that each entity in the exhibition should be independent. So,

when I go there and look at one thing, then I will understand the things that are right here.
Interviewer: Right.
Carl: Without necessarily have looked at previous things.

Carl claims that there are different reasons why people visit exhibitions. He asserts that learning arises differently depending on whether a visitor is at the STC in a school context or whether they attend the exhibition during their spare time, and even emphasizes that that is a *completely different thing*. He thus argues that learning arises differently depending on whether or not the learning activity is organized. Carl's statements about organized and non-organized learning seem to be based on his own personal experiences. According to Carl, visitors do not follow a pedagogical track in an organized way. He points out that during leisure time people visit an exhibition unsystematically. If you follow Carl's reasoning through the excerpt, it is possible to believe that Carl not only makes a distinction between how learning arises, but also implies that the learning outcomes differ depending on how learning is organized. This possible interpretation is reinforced in Excerpt 2, where Ted expresses that there exist different learning outcomes depending on whether these derive from an organized, formal activity or from a non-organized, informal one. This view, held by most of the respondents, expresses that a visitor at a STC may only acquire some products of knowledge when interacting with exhibits.

Excerpt 2

Interviewer: How do you think learning arises when visitors interact with your exhibits?
Ted: … wow … for me is it about creating an interest. Then … and I have always seen exhibitions as some kind of … smorgasbord, you can say, right …
Interviewer: Yes.
Ted: It should tickle their interest and then … then work along on their own … Or how to say it … an exhibition needs not always to give … answers to everything …
Interviewer: No …
Ted: But just to create an interest, since an exhibition can never convey the same quantity of knowledge as a written document for example …
Interviewer: Okay …
Ted: … or a film. One can use writing restrictively, one may use films and so on … and show. But it still turns … that it is about tickling the interest and in some ways entering deeply in other ways …
Interviewer: mm ….
Ted: … and that there arises a communication between visitors that you come together with or … … or visitors that you might meet … visitors and staff, visitors and teachers.
Interviewer: Mm.
Ted: And through this curiosity arises.
Interviewer: Mm.
Ted: The question is how much … how to say … pure knowledge [emphasised] you convey in an exhibition. I'm not sure of that.

Ted does not really answers the question about how learning arises when a visitor interacts with exhibits, but instead claims that it is about creating an interest about

the content. He seems to view exhibitions as a starting point for later knowledge development. Ted thus makes a distinction between creating an interest and learning. In this way he says that learning processes appear differently depending on whether the visitor only becomes interested or actually learns something. A possible interpretation of Ted's reasoning is that it is only possible to reach a 'level of getting interested' if you interact with exhibits. To reach a 'level of learning' you must participate in other activities such as reading a written document or watching a movie. However, he stresses the importance of communication between visitors, staff, and teachers in order to enhance learning. In this way his statements intersect with a socio-cultural approach to learning (Vygotsky, 1986, 1987; Wertsch, 1991, 1998), and this is also pointed out as a crucial context for visitors' learning by Falk and Dierking (2000).

Ted makes a further distinction concerning learning when he reasons about how much *pure knowledge* it is possible to convey from an exhibition. He thereby seems to distinguish general or everyday knowledge from pure knowledge. It is actually not explicit what Ted means by the concept of 'pure knowledge', but a possible interpretation is that he is referring to the fact that scientific knowledge exists as independent of personal experiences. Another interpretation could be that Ted uses 'pure knowledge' in a similar way to Vygotsky (1986) when referring to scientific knowledge as tools for formulating our thoughts about the world.

In Excerpts 1 and 2, Carl and Ted express that learning arises differently depending on the circumstances of the visit, which also results in different learning outcomes. These two excerpts represent examples of what most of the respondents (14 of 17) express about this issue. According to a socio-cultural perspective (Säljö, 2005; Vygotsky, 1986, 1987; Wertsch, 1998) this division risks reducing what learning includes when distinguishing theoretical from practical learning, serious from non-serious learning, formal from informal learning, and organized from non-organized learning. This also means that learning risks are reduced to occurring only in certain specific situations such as in theoretical, serious, or organized contexts. Furthermore, this view tends not to account for visitors' experiences and enjoyment as a part of learning.

Another aim of the study is to investigate what references of knowledge the staff members use when discussing visitors' learning. The respondents were therefore asked to reflect on from where they acquire knowledge in order to develop their understanding of visitors' learning. The analysis showed that more than one-half of the respondents (11 of 17) state that they do not have any scientific knowledge about this subject and that most of them do refer to other staff members who have that competence. However, nearly all of the staff members in this study do not use scientific references, but instead use their *personal* and *professional experiences* as a foundation when reasoning about visitors' learning (15 of 17). This is highlighted in Excerpt 3.

Excerpt 3

Interviewer: From where do you acquire knowledge about visitors' learning?

Lea:	Well, we have a group of educators here who … we assimilate information … some [texts] have been written in this area … and a great deal has been done with both research and written reports and so on …
Interviewer:	Mm.
Lea:	I think that … that … yes … well it is I guess different.
Interviewer:	Yes.
Lea:	We do have teachers here … but when I refer to myself and, then I don't know … one refers very much to … to how one's self works actually … and if I don't catch it, then I guess no one else understands it either.
Interviewer:	No, right.
Lea:	And you watch … one watches … and if one shows exhibitions and things like that, then you know what they ask about right?
Interviewer:	Mm.
Lea:	What is unclear here? What has not been understood? What kind of questions do they ask?
Interviewer:	Mm.
Lea:	And they, you also watch how they move here, what kind of tools they use to understand the content. Do they approach this computer and do they type something? Do they stand and watch these pictures? Do they read the text? You watch that, right …
Interviewer:	Yes.
Lea:	And then you need to find levels that … and that is also a problem I believe that you … you … have such an exhibition that is not directly aimed at kids, it actually isn't at all, but still you have to use a language that works for everyone in some way.
Interviewer:	Mm.
Lea:	… and that, that … and then it can't be too much information either. You must in some way, you want … I think you should stick to at least two different levels in an exhibition.

When Lea is asked from where she acquires knowledge about visitors' learning, she first answers by referring to other staff members who are museum educators. But when she refers to herself, she states that she does not have that theoretical knowledge. She claims that she creates her personal understanding of visitors' learning by referring to how she acts when she faces a similar situation. By that she refers to her *personal experiences*. Further on, Lea refers to her *professional experiences* about how visitors act in an exhibition. In order to acquire this knowledge she observes the visitors, and listens to what kinds of questions they ask and what tools they use. From these experiences and observations she then tries to define at least *two different knowledge levels*. A possible interpretation of this statement is that Lea refers to that exhibitions should offer various degrees of difficulties on order to encounter visitors' different prior knowledge (Anderson et al., 2003; Stocklmayer & Gilbert, 2002).

Apart from assuming personal and professional experiences as Lea does, there were also respondents who claimed that they use their *professional education* and knowledge as a foundation when reasoning about visitors' learning (6 of 17 respondents). This is highlighted in Excerpt 4.

Excerpt 4

Interviewer:	From where do you acquire knowledge about visitors' learning?

Simon:	… well from our background as teachers I would say.
Interviewer:	Yes.
Simon:	I guess we haven't added any new pedagogical ideas so … no, it's our teacher experiences that is the basis of that.
Interviewer:	[…] What theories about learning do use when planning your activities and exhibitions?
Simon:	… well, we do not discuss in terms of Piaget and so, but we talk about the practical learning.
Interviewer:	Mm… can you give me an example?
Simon:	Yes, it is just that, that the visitors are confronted with concrete questions which they solve using simple tools.

When reading this excerpt it becomes obvious that Simon makes himself a spokesman for all the staff members who have a background as teachers. He states that they use their *professional education* as a foundation for their knowledge about visitors' learning. At the same time he argues that this does not include new pedagogical findings or ideas. A possible interpretation is that he does not claim to use scientific sources about learning when they discuss activities or plan exhibitions. This is reinforced when Simon explains that 'the visitors are confronted with concrete questions which they solve using simple tools'.

Apart from personal and professional experiences as well as professional education, a few respondents also allude to *external references* when discussing visitors' learning (4 of 17 respondents). Sarah in Excerpt 5 provides an example of this.

Excerpt 5

Interviewer:	From where do you acquire knowledge about visitors' learning?
Sarah:	… well, when it comes to me it's … I studied science communication as a subject, a qualification then.
Interviewer:	Yes, right.
Sarah:	And then I've worked since, what is it, since 1985 with this. And worked as a teacher … so when it comes to me I've tried to bring what I can to those projects I've worked in … and in other special exhibitions at the centre.
Interviewer:	Mm.
Sarah:	So … it depends a lot, I believe, on the curators previous experiences.
Interviewer:	Yes.
Sarah:	Collaboration with educators. We have museum educators on our staff so to say. That is perhaps the most important part … to emphasise that we have museum educators that have pedagogic education.
Interviewer:	Mm.
Sarah:	And then we have a collaboration with teacher education and with the University.
Interviewer:	In what ways do you cooperate with teacher education?
Sarah:	Yes, we develop some of the programs which they look at … and we also have students doing their practical training here and so …
Interviewer:	Yes.
Sarah:	Perhaps that is important, yes and also engineering students.

Sarah mentions several references where she claims that she acquires knowledge about visitors' learning. She first refers to her *professional education* with a special

emphasis towards science communication. Further on, she points out her *professional experiences* both as a teacher and as an employee at the STC. She also reasons about how other staff members' acquire knowledge about visitors' learning and states that it probably depends upon their previous experiences. This possibly means that she does not refer to their theoretical knowledge about learning, but to the curators' previous encounters. Nevertheless, she points out that the most important part in developing knowledge about visitors' learning is the collaboration with educators. Apart from discussing the personal and the professional references of knowledge, Sarah also refers to collaborations between the STC and universities. These could be referred to as *external references* when discussing from where they acquire knowledge about visitors' learning. The collaboration seems to consist of accepting students for practical training and of creating special programmes aimed at teacher students. However, it is not clear whether their collaboration in addition aims at affecting the content and the design of the exhibitions in order to enhance visitors' learning.

By analysing Excerpts 3–5, it is possible to distinguish four different references of knowledge when it comes to those staff members refer to when reasoning about visitors' learning. The first and most commonly used reference is *personal experiences* emphasized in Excerpt 3, where Lea discusses her own actions when attending an exhibition. In addition she refers to her *professional experiences*, which she has acquired through her informal studies of visitors as to what they do and what they ask about when interacting with exhibits. Another used reference is *professional education*, exemplified by Simon who alludes to his experiences as a teacher. The final reference is *external references* and is shown in Excerpt 5 where Sarah, apart from her professional and personal experiences as well as her professional education, also discusses collaborations with teacher education and universities.

A third aim of this study is to compare what references of knowledge staff members use when reasoning about visitors' learning in relation to how they reason about different references of knowledge within other scientific areas. The respondents were therefore asked to consider where they acquire knowledge about natural science content when planning exhibitions. The analysis revealed that nearly all of the respondents (15 of 17) explicitly said that they use *references from the natural science community* as a basis for constructing exhibitions. This means that to a high extent they have contact with and use researchers' expert knowledge within different natural science areas. A few of the respondents additionally state that they use their own knowledge about natural science or study by themselves to acquire more information within the subject area. In Excerpt 6, Sue describes what references she uses when planning the scientific content for exhibitions.

Excerpt 6

Interviewer:	From where do you acquire knowledge about the scientific content? You talked before about the fact that you cooperated with a technical government authority and …
Sue:	Mm.
Interviewer:	… is it common for you to use external expertise?

Sue:	Yes, we try to do that a lot. It is like this, we, we also have three responsible authorities. We also belong to the University, right.
Interviewer:	Yes.
Sue:	We were in the beginning a project at the university. And then, when we were about to reorganise this … They had to place us somewhere else and we ended up in the local government.
Interviewer:	Mm.
Sue:	But we still have a board consisting of [representatives from] the University, the county council and the local government. So, that is what I mean, we have the possibility to have external help both from the county council […] and the University. So we try to use this. It is important when you do exhibitions, that it isn't free fantasies, right.
Interviewer:	No, right.
Sue:	Because, it should be real things … and we are really careful about this … checking that this is true [laugh].
Interviewer:	Yes.
Sue:	Because it is like this, as time goes, one's own knowledge turns old and many things happen, you notice, right.

During the discussion, Sue has previously talked about the fact that the STC used knowledge of the technical government authority and continues to refer to other scientific references of knowledge when reasoning about the content of the exhibition. She states that having these three different responsible authorities creates special opportunities to incorporate current knowledge about specific scientific areas. She also argues about the importance of these contacts in order to avoid *free fantasies*. Further on, Sue emphasizes this by claiming that the STC needs to examine whether or not the scientific knowledge is true. It is not entirely clear what she means about true knowledge, but at the same time she implies that something exists that can be called true knowledge within natural science. Finally she reflects that her own knowledge about natural science becomes outdated.

When it comes to the natural scientific content in exhibitions, Sue in Excerpt 6, refers to *references from the natural science community*. This is a common reasoning throughout the data and Sue constitutes only one example of this view. This relation to scientific references of knowledge differs from the previous results. In Excerpts 1–4 another commonly occurring phenomenon is explicit. When the respondents reason about visitors' learning, nearly all primarily use their personal and professional experiences. Also professional education and external references are used by some of the respondents. In Excerpt 6, Sue carefully points out that it is important that the natural scientific content not is based on free fantasies. There is thus a discrepancy in what references of knowledge staff members use when reasoning about natural science content in exhibitions, in relation to which they use when discussing visitors' learning. Sue also emphasises the necessity in using other scientific references of knowledge, since her own information about natural science becomes outdated. This view is not found in any discussion about visitors' learning.

Discussion

The principal aims of this article were to investigate staff members' ideas and assumptions about visitors' learning. The results reveal that the respondents refer to learning processes differently by distinguishing organized from non-organized learning, theoretical learning from practical hands-on learning, and serious from non-serious learning. According to most of the respondents, these learning processes conclude with different learning outcomes. It is also evident that most of the respondents express that their exhibitions primarily intend to increase visitors' interest in science and do not emphasize the possibilities for learning. Some of the staff members thereby give the impression of separating the aim of creating an interest from learning. Taken together, the respondents' division of different learning processes and its knowledge products can in this way constitute diametric extremes. This view can be seen as they express a kind of dualistic understanding of learning and knowledge, which could be described as epistemological reductionism.

But what consequences does this approach to learning bring? An obvious risk is that visitors' learning is only seen to occur in certain specific situations and does not account for enjoyment and experiences as learning. This view might lead staff members to not realize the possibilities for learning that could be provided to visitors. In a socio-cultural approach, a crucial assumption is that learning processes derive from the all social and cultural interactions we are exposed to through encounters with others and our environment (Säljö, 2005; Vygotsky, 1987; Wertsch, 1991). In a STC context this could mean that when visitors interact with exhibits or with each other, new thoughts may be mediated independent of whether the situation is non-organized, non-serious, or hands-on practical. According to a socio-cultural perspective, it is hence possible to understand the visitors' learning from how they interact with peers and curators as well as the available activities in exhibitions.

Another aim of this study was to explore the references of knowledge staff members refer to when reasoning about visitors' learning. The results revealed personal experiences, professional experiences, professional education, and external references as four main sources. However, most of the respondents depend upon their own personal experiences when reasoning about visitors' learning. When it comes to professional experiences, some respondents conduct informal observations of what the visitors do and what they ask about. However, 11 of 17 respondents explicitly state that they do not have any scientific knowledge about learning despite the fact that they work with the planning and construction of new exhibitions. Meanwhile it is possible to identify that some respondents' reasoning intersects with existing theories about learning. For example, a few of the respondents emphasize the importance of visitors' communication in order to enhance learning, which is also pointed out by Falk and Dierking (2000) in the contextual model of learning. It is also possible to discern that some respondents refer to visitors' prior knowledge (Anderson et al., 2003) as a crucial factor to be able to understand how visitors' learning is developed through interaction with exhibits. This factor is also a prerequisite for learning in the PAST framework of Stocklmayer and Gilbert (2002).

When it comes to how respondents reason about the natural scientific content, a completely contrasting image appears. Nearly all of the staff members explicitly express that they use references from the natural science community and refer to researchers' knowledge when constructing new exhibitions. Unfortunately, this study is not able to explain why staff members express this clear difference in how they relate to the natural science content compared with how they relate to visitors' learning. Do staff members view visitors' learning as an area in which it is impossible to raise questions and construct scientific models in order to describe learning? Or do staff members experience the existing models as irrelevant when planning new exhibitions?

When discussing theoretical models of learning, Falk and Storksdieck's study (2005) and the contextual model of learning (Falk & Dierking, 2000) highlight the complexity of describing the individual factors that are decisive for visitors' learning. However, a model aimed at describing all possible factors that might influence visitors' learning risk losing focus on the essence of a theoretical model of learning. This means that the visitors' meaning-making processes and their actions when interacting with exhibits tend to be out of focus when studying learning at STCs. The contextual model also does not seem to consider the combination of different theoretical frameworks. Consequently different epistemological approaches are used, which can be problematic to combine. An example of this is the use of an individual constructivistic approach to learning and an attempt to implement a socio-cultural perspective.

A socio-cultural perspective (Säljö, 2005; Vygotsky, 1987; Wertsch 1991) focuses on meaning-making processes, which have their origin in interactions between individuals and between individuals and different tools or signs. This means that the relation between the visitors and the exhibits could constitute the core of a model of how learning arises at STCs. It is thereby possible to understand and to study how visitors take action when interacting with provided mediational means. This means that we may study in what ways different tools and signs mediate the visitors' thoughts and actions. The exhibitions can in this way be viewed as tools or artefacts that to different extents enable mediation. From Kozulin's (2003) reasoning about mediation of meaning, it is possible to study to what extent exhibitions make cultural conventions and cultural development explicit. But it is not until visitors interact with exhibits that it is possible to investigate how the exhibits accomplish support for the development of new psychological tools. Thus, the relation between visitors and the accessible resources in an exhibition can form a foundation for a model aimed at understanding how learning arises and develops at STCs. Such a model could, in addition, constitute starting points and guidelines for staff members when planning and constructing future exhibitions.

However, Kozulin (2003) argues that mediation is not for granted and claims that tools and signs only derive their meaning from the embedded cultural conventions. This means that when an artefact is separated from its cultural milieu and put on display in an exhibit, it risks losing its mediational potential. It is therefore necessary to re-provide mediational qualities to the artefact through visualizing processes that

engender the artefact and display its cultural–historical background. The situation also needs to focus on the visitors' metacognitive awareness about the tools and signs in the artefact. The concept of mediation could thus be used as a tool when creating new exhibitions and may address questions for the staff members such as: What do we want the visitors to focus on and discuss when they encounter this artefact? What actions do we wish visitors to take when interacting with this tool? How can we implement an artefact into an exhibition without loosing its mediational qualities?

This study has actually only explored staff members' reasoning about learning on display. This means that we have investigated how staff members claim to reason when planning new exhibitions and not in what ways they really refer to learning in action. Future studies therefore could take an ethnographic approach and focus on staff members' actions and assumptions about learning when constructing new exhibitions.

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IV

Economic interests and science exhibitions

A study of how sponsors may affect exhibition contents

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Abstract

Science and technology centres (STC) have been criticised for displaying a too product-oriented and single-dimensioned image of science. But what possible explanations could there be to this phenomenon? What assumptions and factors affect how science is constituted in exhibitions? This article focuses on discussing possible factors, which could affect the final content and design of an exhibition and in particular explore the impact of sponsors. The analysis from the interviews and from the participant observation reveals that sponsors are, in many cases, crucial for the work at STCs. However, several staff members, who work with planning and constructing new exhibitions express that sponsors may interfere with the content and the design both indirectly and directly. Indirect impact refers for example to implicit demands where staff members account for what they believe are views of the sponsors as it is expressed in the discussion about self-censorship. Direct impact on the other hand refers to sponsors' explicit demands of being visible in the exhibition or demands concerning the content of the exhibitions. This means that staff members seem to need to take into account sponsors possible views and demands both in advance and during the planning of new exhibitions.

Introduction

Museums and science and technology centres (STC) have been criticised for displaying a too product-oriented and unproblematic image of science in exhibitions (e.g. Pedretti, 2002, 2004; Rennie and Williams 2002). This critique seems also valid in the study of Davidsson and Jakobsson (2007) as they explore the aspects of science which staff members choose to display in their exhibitions. The results reveal that the staff members, to a large extent, select the aspects *science in society, science in a technical perspective, how modern science is generated and scientific facts*. These constitute the common image of *the usefulness of science* and describe

science in terms of good things which can be achieved through science. This image is well in line with the critique of displaying a too product-oriented approach to science in exhibitions. The results from Davidsson and Jakobsson (2007) also show that certain aspects of science such as controversial issues, values and science from other cultures tend to be excluded from exhibitions.

But what are the consequences of these exclusions? In what ways might visitors perceive the science described in these exhibitions? Rennie and Williams (2006) explored how adult visitors consider science and the nature and use of scientific knowledge. Data was collected before and after visitors either attended an exhibition at a science and technology centre (STC), an exhibition at a natural history museum or a public lecture. The results suggest that independent of venue, the visitors were, after the visit, more likely to become less scientific in their reasoning about the nature of scientific knowledge and more likely to believe science is infallible. These results could mean that exhibitions risk losing important aspects of science and of how science knowledge is constituted. Davidsson (submitted) argues that staff members' conscious avoidance of displaying uncertainties and controversial issues risks leaving unfulfilled, the aim of increasing visitors' interest in science. Riess (2004) argues that to be introduced to such a reductionistic view can be one reason why young people feel unengaged in science. But why does there seem to be a tendency to display science in an unproblematic and certain way in exhibitions? What assumptions and factors affect how science is constituted in exhibitions?

The purpose of this article is to discuss different possible assumptions and factors which could affect how science is constituted and outlined in exhibitions but in particular to explore the role of economic interests. This means to investigate how staff members' consider the impact of sponsors on the scientific content of an exhibition.

Background

Staff members' impact on the content and the design of an exhibition

Davidsson (accepted) explored how staff members consider the scientific content in their exhibitions and how they consider displaying scientific issues about which scientists have not yet reached consensus. Several staff members expressed an anxiety about displaying different

researchers' view points or ambiguous answers because this could risk questions about the credibility of the museum. Another explanation, also discussed in this study, considers whether the nature of scientific knowledge is excluded due to the fact that staff members hold limited views of the nature of science. The results however, do not support such reasoning. The staff members were asked to consider statements about consensus and infallibility of scientific knowledge and the relation between science and society. The results indicate that the respondents do understand the tentativeness and consensus of scientific knowledge as well as for societal and human aspects of science. These results are well in line with the results of the study by Rennie and Williams (2002) where they found that the interviewed staff members, in general, held a broad view of the nature of science. This means that science exhibitions, which display the *usefulness of science*, do not seem to be a result of limited views held by staff concerning the nature of science.

But, Davidsson (accepted) also explored to what extent the staff members believe that *all people need knowledge about scientific concepts and phenomena*. The mean value of this statement was very high (6.6 on a 7-grade scale) and furthermore, the standard deviation indicated that the respondents strongly held this view. The staff members also considered to what extent they believed that *all people need knowledge about how new scientific knowledge is generated*. This statement also got a high mean value (5.4) but the answers were more spread out. Thus, the results indicated that staff members tend to consider scientific knowledge about concepts and phenomena to be more important to know about than knowledge of how new scientific knowledge is generated. But, within the enterprise of science education, acquiring knowledge about scientific processes and how new scientific knowledge emerges is considered crucial in order to develop a broad understanding of the scientific content (e.g. Driver, Leach, Millar & Scott, 1996; Hodson, 1998). Also within a sociocultural approach to learning, Kozulin (2003) argues that in order to learn content knowledge it is crucial to also appropriate mediational means as general instruments with which to organize individual cognitive and learning functions in different contexts. These mediational means should therefore be deliberately introduced, systematically acquired and emphasise the general nature and applications. From this reasoning, another assumption, which could affect how science is constituted in exhibitions, is that staff members, who plan and construct exhibitions,

hold a limited understanding of visitors' learning and that this affects the constitution of science in exhibitions.

Davidsson and Jakobsson (accepted) explored staff members' approaches to visitors' learning when interacting with exhibits. The participants in the study were all responsible for planning and developing new exhibitions and were asked to consider in what ways they believe visitors learn from their exhibitions. The results suggest that the staff members refer to learning processes differently depending on the context of the visit such as organised – non-organised learning, theoretical – practical hands-on learning or serious – non-serious learning. According to most respondents, these different processes conclude with different learning outcomes. The authors argue that there is an obvious risk *that visitors' learning is only seen to occur in certain specific situations and do not recount for enjoyment and experiences as learning* (p. 17). There is thus a risk that staff members do not realize and use provided possibilities for learning in a STC setting. In the same study, the staff members were also asked to describe what references to knowledge they used both concerning visitors' learning but also when it comes to the scientific content of the exhibitions. The results show a discrepancy in their reasoning as most respondents referred to their personal experiences when it came to visitors' learning but when considering the scientific content they all referred to the natural science community and researchers' knowledge when constructing exhibitions. It was, however, not possible in this study to draw any conclusions as to why this discrepancy occurred.

From this discussion, it seems that staff members, in general hold a broad view of the nature of scientific knowledge. It is therefore likely that product-oriented exhibitions, which focus on the usefulness of science, are not a result of limited views of what science may be. In that case, this could mean that the staff members' views of the nature of science, do not have a decisive influence on how science is constituted in exhibitions. However, when it comes to visitors' learning, the staff members seem to hold more narrow views of what learning may be. This indicates that the staff members' views of visitors' learning, to a high extent, may influence how science is constituted in exhibitions. Staff members' limited awareness and narrow understanding of learning has been criticised in other studies. For example Cox-Petersen, Marsh, Kisiel, and Melber (2003) found little coherence between the pedagogical approaches of the

school guided tours and the recommendations from formal science standard documents and literature about learning in informal settings. Instead they found that staff, who led guided school tours, did not invite the students into dialogues, kept a fast pace and used many scientific concepts without discussing their meaning. Also Tal and Morag (2007) criticise the staff members' approach when conducting guided tours as they, to a large extent, used scientific terms which were poorly explained and posed questions which only required simple and straightforward answers.

So far, staff members' views of the nature of science and their ideas about visitors' learning have been discussed, but what other factors and assumptions could affect how science is constituted in exhibitions? In what ways do the visitors affect the staff members' decisions when constructing an exhibition?

Visitors' indirect impact on the content and the design of an exhibition

A large part of the visits to STCs and museums are school group visits (e.g. ASTC, 2007) which are conducted in the context of fieldtrips. Kisiel (2005) argues that teachers view these fieldtrips as educational events but several studies indicate that teachers seldom relate the visit to pre- and post-activities in order to enhance learning outcomes (e.g. Tal, Bamberger and Morag, 2005; Griffin and Symington,1997). Kisiel (2005) furthermore concludes that teachers emphasise the importance of the topic of the exhibitions corresponding to what is being studied in school. But Griffin and Symington (1997) argue that the teachers tend to make little effort to link the experiences from a fieldtrip to school topics. In order to bridge the gap between the fieldtrip and the activities in school, Dewitt and Osborne (2007) developed a theoretical framework as a resource for museum educators to be able to meet the needs of the teachers. Such a framework, when used, could affect how science is constituted in exhibitions, since it suggests that staff members should consider national curriculum standards and relate the exhibition content to students' experiences.

MacDonald (2002) highlights other possible factors which could affect the constitution of science in exhibitions. She followed a design team when constructing a new exhibition at a science museum and found that the staff members tried to imagine visitor responses on questions such as 'Will they understand?', 'Will they become fatigue?' and 'Will they find

their way around the exhibition?' She concludes that the team tended to evoke a standardised visitor in the sense of an abstract vision of a fairly coherently behaving visitor as a guide during the planning and construction. The visitors thereby indirectly affect the constitution of science and the design of the exhibition, since the staff members seemed to try to oblige visitors' expectations, agendas and interests. It is however not explicit in what ways these approaches actually affect the content and the design of the exhibition. But Macdonald (2002) also highlights the impact of donors and sponsors which could be seen as an additional factor which, apart from the staff members and the visitors, seems to influence the content and outlining of exhibitions.

Sponsors' impact on the content and the design of an exhibition

In order to realise an exhibition idea at a science museum, Macdonald (2002) describes the need for the staff members, who participated in her study, to acquire sponsorship. This means that sponsors were prerequisites for making the exhibition possible. This example does not seem to be an exception within the field of museums as the use of sponsors has tended to increase over the last four decades. For example, Alexander (1996) analysed annual reports from 30 different art museums in the US and found that those museums have become more dependent on external funding during the 70ies and 80ies. McPherson (1997) argues that the need of external financial support has gradually increased due to the pressure on museums from ministries and governments for self sufficiency. But it seems like different sponsors such as companies or government tend to fund different exhibitions. Alexander (1996) found that corporate funding of art exhibitions tends to encourage blockbuster exhibitions and travelling exhibitions which are popular and attract large audiences. Corporations are less likely to support controversial art exhibitions unless the artist is already known. Government funding also supports blockbuster exhibitions but in addition encourages scholarly exhibitions which rest on art historical research and attract a smaller audiences. But Macdonald (2002) concludes that the sponsors are clearly expecting something for their money and they are only likely to support exhibitions which relate to a subject of interest to them. The sponsors of science exhibitions in her study influenced exhibition design, since the main financier demanded that their name should be permanently and exclusively associated with the exhibition. But in what ways could the

need for sponsorship affect the museum enterprise and exhibition designs?

In order to meet new financial demands, McPherson (1997) argues that museums increasingly have adopted political and social policies which have the potential for bringing additional funding and benefits. She contends that this has changed the role of the local museums towards institutions which traditionally provide not only education opportunities but also entertainment, catering and shopping. This means that museums compete, both with other museums, as well as against other leisure activities, such as theatres, cinemas, restaurants, etc. As a consequence of this development, McPherson (2006) argues, museums increasingly have become tourist attractions and cultural service is viewed as predominantly economic rather than as social entities. Another consequence is a changing role of museum staff which gradually has become more diverse as marketing has become part of the job requirements for staff with other preoccupations. One example of this change is provided by Bouquet (1998) as she describes a policy change at the Dutch National Museum of Natural History. The museum moved from being "a pure scientific institution towards developing a clear orientation towards the public" (p 160). This also meant a shift in the balance of power within the staff group as the scientific staff were now supposed to be supportive rather than in the role of giving directive advice. But Kotler and Kotler (2000) state that applying such strategies risks leading to a diminishment of core activities such as collections, scholarship and education.

Yet another consequence of the need for sponsorship can be seen in the content of exhibitions. Macdonald (2002) reveals that sponsors may interfere with what is to be presented, as they are able to persuade staff members to accept a particular topic through mobilising a rhetoric of *the facts*. Also Gieryn (1998) describes the impact of sponsors when studying the difficulty in constructing and presenting a controversial historical exhibition. He concludes that the both curators and different stakeholders urge for a balanced exhibition where the visitors are not steered towards one or a few of many available interpretations of historical events. However he shows that balanced exhibitions have different interpretations to different groups involved. This means that when curators want to include ambiguous or controversial interpretations of historical events, they risk being considered as creators of an unbalanced exhibition by stakeholders or different interest groups.

This discussion refers predominantly to traditional museums such as historical museums, art museums or natural history museums, but in what ways does it correspond to the economical situation of STCs? Perhaps was the demand for self sufficiency was already a reality at the start of this movement? When a large Nordic STC opened in 1988, it was made possible through donations from different foundations (Experimentarium, 1990). The list of different sponsoring foundations and companies, which contributed to the establishment of the STC from the start until October 1990, is extensive. In addition, when it comes to separate exhibitions, these seem to have been made possible through different sponsorship. Kattler (1996) describes how the development of an exhibition about the brain was made possible through donations. Another large Nordic STC has a similar background. When it opened in 1988, 120 donators and sponsors contributed to the financing of buildings, exhibitions, equipment, and interiors. Main financiers were large companies within the engineering, mining and forest industries. Today local governments and a university sponsor about 25% of the museum's working costs. However the remaining costs must be covered by incomes from admission fees, the shop and the restaurant as well as from other activities related to the STC but also from sponsorship (www.teknikenshus.se).

As seen in this discussion, sponsors and donors seem to be crucial for the development and construction of new exhibitions at both museums and STCs. However the need and involvement of financiers also seems to have consequences when it comes to the content and the design of exhibitions.

The study

The previous discussion highlighted three factors which could affect how science is constituted in exhibitions: the staff members own assumptions about what should be included and about how to present the scientific content in order to support visitors' learning, the visitors' indirect impact as the staff strives to oblige visitors' agendas, interest and expectations and, finally, the impact of the economic interests and sponsors. But in what ways do staff members at STCs consider and handle economic interests and sponsors when planning and creating new exhibitions? The aim of this study is to explore how the staff members consider the impact of economic interests on a final exhibition.

The research question is:

- In what ways do staff members at STCs experience an influence from sponsors on the constitution of science in exhibitions?

Methodological considerations

This study is part of a larger project which aims to explore how science is constituted in exhibitions. The first part sought to identify what aspects of science staff members choose to display in exhibitions and how these aspects constitute different images of science. The study was based on answers to questionnaires from 66 staff members from 30 different Nordic STCs (Davidsson and Jakobsson, 2007). The second part involved exploring staff members' views about visitors' learning and was based on interviews with 17 staff members from 11 different STCs (Davidsson and Jakobsson, in press). The respondents were chosen through purposive sampling (Silverman, 2001; Patton, 2002). The criterion for selection was that they should be responsible for designing and creating new exhibitions at their STCs. The third part intended to study staff members' views of the scientific content in exhibitions and was based on both the interviews and the questionnaires (Davidsson, accepted). However, as the interviews aimed at focusing on staff members' views of visitors' learning as well as their views about the scientific content in exhibitions, another issue, which seemed to affect how science is constituted in exhibitions became evident. Without any initiative from the interviewer, some respondents discussed episodes where economic interests and sponsors had had an impact on the content of their exhibitions.

In order to explore how economic interests affect the constitution of science in exhibitions, a third collection of data through participant observation was carried out. A STC was contacted and after having discussed the research topic, it was possible to join a development group in which the members discussed and decided on forthcoming exhibitions. The four members in the group had backgrounds as engineers, scientists and communicators. 16 group meetings were recorded (40 hours) over a period of five months and in addition included a personal meeting with each of the members as well as a meeting with one member of the

management group. However the analysis of this empirical material showed that economic issues in relation to the scientific content of the exhibitions were discussed to a low extent in this forum. Therefore the participant observation was followed by a focus group interview with the same group which lasted for one and a half hours. This interview focused on two main questions *What factors do you believe have an impact on the scientific content of the exhibitions* and *In what ways do you believe economic issues impact the scientific content in the exhibitions*. To be able to explore the research question for this study, all phases of data collection, questionnaire, interviews, participant observation and the focus group interview are included in the analysis.

Analysis

The questions in the questionnaire aimed at providing a background with which to explore to what extent STCs are dependent on external economic support. These questions were therefore analysed through descriptive statistics were the use of sponsors became explicit. The analysis further revealed to what extent sponsors interfered when the staff members created new exhibitions. The interviews, the participant observations and the focus group interview were then analysed in two-phases analysis (Patton, 2002). In the first phase, all situations in which the staff members discussed economic issues in relation to the content of the exhibitions were identified. In this phase, it seemed like the respondents referred to two different ways in which sponsors affect the construction of exhibitions:

- Sponsors' *direct* impact on how science is constituted in exhibitions
- Sponsors' *indirect* impact on how science is constituted in exhibitions

In the second phase, these two categories were successively described and resulted in different subcategories. When it comes to sponsors' direct impact it seemed like the respondents referred to two different kinds of demands: restrictions or decrees in the chosen scientific content and pronounced demands from the sponsors of being visible in the exhibitions. The second category, sponsors indirect impact, also seemed to contain two subcategories: self-censorship and allowing the sponsors

to participate in constructing new exhibitions. The second phase sought to test, verify and confirm these categories. The data material was interpreted by two independent coders in order to increase the reliability of the analysis.

Results

A general view of the use and involvement of sponsors at Nordic STCs

The aim of the questionnaire was to obtain a general view of the extent to which sponsors are used and involved when staff members at Nordic STCs create new exhibitions. The analysis shows that 68% (45 of 66) of the respondents said that there were sponsors for their latest exhibition. 23 % (15 of 66) argued that there were no sponsors and 9% (6 of 66) did not answer the question. The questions which follow concerned only those respondents who said that there were sponsors involved in their latest exhibition. The sponsors seemed to be engaged in the work of constructing the exhibitions in different and sometimes several ways. About 2/3 (31 of 45) of the respondents stated that they received economic support to be able to construct the exhibition. Also about 2/3 (34 of 45) received support as the sponsors contributed material for the exhibition and 2/3 (31 of 45) stated that the sponsors contributed scientific knowledge. One-fifth of the respondents argued that the sponsors contributed in other ways, but those were not specified.

The respondents were also asked to comment on whether the sponsors affected the exhibition and in those cases in what ways. About half of the staff members (25 of 45) argued that the sponsors did not influence the content or the design of exhibitions. Consequently 20 respondents argued that they did in one or several ways and nearly all of them (16 of 20) experienced interference from sponsors in the choice of the scientific content. More than half of the respondents (13 of 20) stated that the sponsors had viewpoints about how to display the content and about just as many (11 of 20) said that the sponsors wanted to show their profile in the exhibition. The sponsors had an exchange of the financial, material or knowledge support in two thirds of the cases. Half of these got publicity through the exhibition and the other half stated that the sponsors had other beneficial advantages.

However, the results also indicated that sponsors are considered differently depending on the situation and for what purpose the financial

support is needed. One respondent argued, in an interview, that there is a distinction between sponsors and donors. He argued that sponsorship is economic support directed to a specified project, such as a temporary exhibition, with a well defined content. Donations, on the other hand, are described as revenue sources to broad projects, given on the background of an application with an outline of a project, such as renewal of the permanent exhibition.

The results from the questionnaire thus indicate that to a high degree, the STCs, where the participating respondents work seem to be dependent upon external funding. In addition, more than half of the respondents in addition express that the sponsors interfered with the planning and construction of an exhibition. This interference is also visible when analysing the data from interviews, observations and the focus group interview. The results indicate that the sponsors actively influence the construction of an exhibition.

Sponsors' direct impact on how science is constituted in exhibitions

During the interviews some respondents discussed instances where the sponsors had had an influence on what and also how the content should be presented. In these cases, the sponsors were a part of the team that planned the exhibitions and/or sponsored the exhibition on different conditions. For example, one respondent expressed that an exhibition about healthful living was sponsored by the health ministry with the condition that only what is commonly accepted as scientific knowledge about health and nutrition should be displayed in the exhibition. This means, for example, that it was not possible to scrutinize pseudo scientific health advice in relation to scientific knowledge. Another example of how a sponsor interferes with the content of the exhibition is provided in Excerpt 1 where Edith, a exhibit designer, discusses a cell phone exhibition and a sponsor interrogates her about what was presented.

Excerpt 1

Interviewer	Were there different opinions about displaying different models of explanations?
Edith	[emphasising that this is her view] Well you can choose one system or otherwise you say that these systems exist and then you account for both.

Interviewer	Mm…
Edith	I think that is the most natural
Interviewer	Right… in general, do you believe such areas are excluded or…
Edith	I don't think so…
Interviewer	No…
Edith	That is a little bit exiting […] personally I believe that it is much more fun if there are…
Interviewer	Yes…
Edith	But, sure it can… I can tell when I worked with another exhibition about cell phones I had lectures about this radiation thing and that was not fun…
Interviewer	Mm…
Edith	As this large company had sponsored the whole exhibition and they were not pleased and they had viewpoints on the content even when we had a researcher who commented on radiation…
Interviewer	Okay…
Edith	And there we were forced to make some changes
Interviewer	So this company demanded that you should change things in your exhibition…
Edith	Yes they did…

Edith is asked whether there were different opinions about displaying different models of explanation and she argues that if there were two explanations, it would be the most natural to display both of them. However she tells about an episode where the sponsor explicitly demanded that an explanatory model concerning the relation between cell phones and radiation should be left out. This meant, she argues, that they had to change the content of the exhibition in order to oblige the sponsor's demands. She does not mention why the sponsor made this demand, but it is possible to believe that one reason was that the sponsor thought of discussions about radiation as negative publicity in relation to their company's products. Her experience concerning how a sponsor actively interrogates about the scientific content of the exhibition might not be unique since the results from the questionnaire reveal that about 1/3 of the staff members, who had sponsors to their latest exhibition, said

that the sponsors interfered in what should be displayed in their exhibitions.

Yet another example of how sponsors influence the constitution of science in exhibitions is provided in the following excerpt (Excerpt 2) where Cindy, an exhibit designer, discusses how they try to satisfy the sponsors' demands of being visible in the exhibition.

Excerpt 2

Interviewer	When discussing this sustainable development exhibition, what problems did you encounter concerning describing the scientific content?
Cindy	… yes… I don't think we had any problems
Interviewer	No…
Cindy	No, the problem to us is, I can tell, to relate to the industry.
Interviewer	Yes…
Cindy	And the industry has its own view of this and we have ours and meanwhile, the communication [between the industry and us] doesn't work very well. They believe they can and have knowledge [about science and technology]. It [the knowledge] is just supposed to transfer to us, that we should understand how they think… but we don't…
Interviewer	Okay
Cindy	Actually it is to get industry related experiments established at a scientific level. That is the problem.
Interviewer	Yes… do they interfere in some ways in how you present…? And what…?
Cindy	Yes, they want to be visible in someway, but they don't come with concrete…

Cindy does not seem to experience the presentation of science as problematic. Instead she refers to the difficulty in displaying the scientific content in ways that will relate to the industry. According to her, the sponsors from industry and the staff members hold different views of what to present but she does not explicate the differences. However, she says that the communication between the staff members and the sponsors

is inferior. Cindy argues that the sponsors interfere in both how and what they choose to present in the exhibition with the demand that they want to be visible to the audience. This reasoning does not seem to be unique as the results from the questionnaire, discussed above, indicate that about one-fourth of the respondents, who had sponsors for their latest exhibition, expressed that the sponsors wanted to show their profile in the exhibition.

In Excerpts 1 and 2 Edith and Cindy discussed how sponsors made demands on the scientific content in two different ways. In the case of Edith the sponsors demanded that the staff remove parts of the exhibition and in Cindy's case the sponsors wanted the staff members to construct an exhibition in which the audience could experience the involvement of the sponsors. In both situations, the sponsors actively and explicitly made demands concerning the scientific content and/or the design of the exhibition and thereby also influenced the constitution of science in the exhibitions. From this reasoning it follows that the sponsors seem to have a *direct impact on how science is constituted in exhibitions*. This means that sponsors, through active engagement in the process of constructing an exhibition, have opportunities to affect what should and should not be displayed. However, further analysis reveals that the sponsors not only have the possibility of direct impact, but may also influence the constitution of science in exhibitions without making explicit demands.

Sponsors' indirect impact on how science is constituted in exhibitions

From the analysis of the participant observation and the focus-group interview, it seemed that the sponsors also had an impact on the content of the exhibition without explicitly making demands as they did in the instances of direct impact. The focus-group participants were asked whether they had experienced direct impact from the sponsors and their discussion is highlighted in Excerpt 3.

Excerpt 3

Interviewer	Now you have given me examples of exhibits which you have chosen yourselves not to display, but have you found that the sponsors have asked questions and said that "we don't want you to show this"?
Steve	No, I don't think so actually, have we?

Mary	Not what I can remember…
Sally	But, perhaps we've done it ourselves?
Steve	Self-censorship…
Sally	I don't know if I have any examples, but sometimes we say that this won't work when we have these sponsors, don't we?
Mary	Well…
Tom	In the healthful living exhibition we actually had a discussion about what is right and wrong and we concluded that we would follow the official standpoints concerning health. Because we could have done something about alternative treatment and…
Mary	And other theories about…
Tom	… we actually chose not to display this for this reason…
Interviewer	Was it the Ministry that sponsored?
Sally	No, it wasn't like they sponsored without demand
Mary	They donated a great amount of money, but it was something we…
Tom	Self-censorship in that way…
Sally	Yes we have self-censorship
Tom	That discussion we had then…
	[…]
Steve	I think, when talking about censorship… it sounds dangerous when you call it censorship. But you could call it guiding principles or whatever… guiding positions. We are to some extent… we have some responsibility for what we are doing and being responsible, I believe first and foremost, I mean the responsibility for the scientific content […] But if you ask Larry [a colleague] he would per default argue that it is self-censorship due to political reasons. And I've heard others who say so. I've heard it…
Mary	Due to political reasons?
Steve	It's several years ago now, but
Mary	What do you mean by political reasons?
Steve	Yes, yes, people say that at our STC they are forced to compromise for commercial reasons in what they do.

Yes, I've heard people say that.

The respondents are asked whether they found that a sponsor actively interfered with the content of an exhibition. None of the staff members had, but they instead reflected upon whether they had changed the content on their own initiative due to present sponsors. Steve directly labels this self-censorship and they together try to come up with an example or an episode to highlight this phenomenon. Tom suggests that this happened in the healthful living exhibition where they decided to only display official standpoints concerning these issues. However Sally seems to object when saying that they did not sponsor the exhibition without demands on the content and the design. But the others argue that that was self-censorship and Sally agrees. Steve seems then doubtful in labelling this phenomena self-censorship and claims that most important is responsibility for the scientific content. Finally Steve says that there are others who say that they need to compromise and he relates this to self-censorship.

One respondent also discusses the healthful living exhibition during a personal meeting and a slightly different image appears about the interference of the Ministry of Health. He argues that the Ministry of Health did not want to influence the exhibition and also that it would have been impossible for them affect the content. However he argues that the management of the STCs wanted the Ministry's approval of the advice for healthful living given in the exhibition and had asked the staff members only to display official standpoints.

However the discussion among staff members indicates that they seem to feel that they need to consider the sponsors' profile, what they believe the sponsors would agree on and adjust the content of the exhibition in ways that will appeal to the sponsors. This means that the involvement of sponsors risks leading to situation where the staff members are restricted in their choices of what to display in exhibitions.

But the staff members also seem to experience another way in which the impact of sponsors is felt since the staff tends to make allowances for the sponsors as one part in the process of constructing a new exhibition. The following discussion (Excerpt 4) starts with information about the rejection of an application for external financing from a large foundation. The staff members continue to discuss what they should do and how fundraising should be conducted in general.

Excerpt 4

Tom	…and we have more bad information… from the Eleanor-fund
Steve	What does it say?
Tom	They don't want to support the children's exhibition
	[…]
Tom	That's it, I'll talk with Robert [the director] about what we should do now… we will decide on where to apply for money and so…
Mary	We can also consider whether we think there is money or also maybe construct another project
Tom	Yes
Steve	How much was awarded from the Eleanor-fund?
Mary	Nothing at all!
Steve	Well…
Mary	Robert just came up with that he should apply for money [at the Eleanor-fund] because he thinks they give… and give to anything…
Steve	Okay
Tom	Well, they don't…
Mary	Not when you treat them that way anyway, right?
Steve	The way that you present the activity?
Mary	Yes, and he fills in an application which will be sent by mail… They [the sponsors] want to be engage and join and feel that they are a part of this and…
Tom	Yes
Steve	And we didn't know that in advance?
Mary	I'm sure we did… […] Exactly the same thing happened with the newspaper concerning "try the world" (?) also just sending it by mail. And they were so irritated as sponsors… they were so engaged and wanted to be a part of issues about developing countries. They were just so annoyed. But they shouldn't just get a letter saying [inaudible] one million at our STC. Who has the energy to that today?
Steve	No, no… but, but what you're saying is a serious critique against our way of doing fundraising. Do you think we have an old fashion way of fundraising?

Mary I believe so and it still works at some of these old funds…
Steve Those that have a lawyer's address or…
Mary Right
Steve Yes
Mary But it doesn't work on those large funds, which use their funds to show that they practice charity and support good things. They constantly need to motivate, in relation to their business, which is why they use the money in exactly that way… and that could be a lot easier if they are a part of the project, right?

The staff members suggest two ways in which they can approach the problem of the application rejection, to apply for money elsewhere or modify or reconstruct the project. However Mary objects to the way this application was submitted and argues that the sponsors need to be treated differently. The staff members, and in particular Mary, then discuss a possible way of doing fundraising which also involves engagement of the sponsors. According to Mary, sending a letter is an old fashioned way of gaining sponsors and instead the staff needs to involve the sponsors so they become an active part of the project. This way of aiming your application towards a specific sponsor or donor is partly confirmed by another respondent. He argues that donors only want to support "good projects"; projects with content which is relevant and considered as engaging for the public and with an extensive use of hands-on activities. Furthermore, he says that controversial or tentative content may therefore be difficult to finance.

Excerpt 3 and Excerpt 4 highlight another level of impact which the sponsors have on the process of constructing exhibitions. In Excerpt 3 the staff members seem to experience a self-censorship in relation to the sponsors and in Excerpt 4 they need to consider the sponsors in order to start a new project. In both of these cases the sponsors seem to have impacts on the content and the design of exhibitions but it is not explicitly stated. Instead there seems to be implicit demands as they for example have the power to reject a project. It is therefore possible to believe that sponsors and donors in different ways have *indirect impacts* on how science is constituted in exhibitions.

Discussion

The starting point for this article was the critique of STCs for displaying a too product-oriented and single-dimensioned image of science. In order to explore the underlying causes of this tendency, we sought to discuss different possible assumptions and factors which could affect how science is constituted in exhibitions. This discussion highlighted three different perspectives: staff members' impact, visitors' indirect impact and sponsors' impact on the content and the design of exhibitions. The main aim of the study was however to explore how staff members experience and consider the impact of sponsors on the scientific content of the exhibitions.

As seen in the previous background discussion, sponsors and donors are, in many cases, crucial for the work at museums and STCs. In fact, several STCs and museums are dependent on financial contribution of sponsors. However, the cooperation between sponsors and the staff members who construct the exhibitions also risks clashes and differences of opinions concerning what and how the scientific content is to be displayed. This can be seen from the results of this study as the respondents, who in the questionnaire stated that they used sponsors in their latest exhibition, experienced interference from sponsors with both the content and the design of their exhibitions. However the results also reveal that the issue about sponsors' and donor's impact on exhibitions is more complex as they may influence the exhibitions in different ways, indirectly and directly. Indirect impact refers to implicit demands where staff members account for what they believe are views of the sponsors as it is expressed in the discussion about self-censorship. Furthermore, indirect impact also refers to instances, where staff members already before the start of a project, consider the perspective of different possible sponsors or donors. Direct impact on the other hand refers to sponsors' explicit demands of being visible in the exhibition or demands concerning the content of the exhibitions. Staff members may also try to include sponsors in the process of constructing an exhibition. This means that staff members seem to need to take into account sponsors possible views and demands both in advance and during the planning of new exhibitions. But what consequences does this bring concerning the constitution of science in exhibitions?

Macdonald (2002) argues that sponsors expect something in return for their economical support and from the results of this study, staff members

seem to be aware of this when applying self-censorship or involving sponsors in the process of planning an exhibition. However Gieryn (1998) describes the difficulty in also including controversial issues and different interpretations of events while being dependent on sponsors. This could explain why staff members in the study of Davidsson (accepted) were likely to exclude different explanatory models of scientific phenomena or ambiguous answers from exhibitions. But what possibilities do minor operators or economically weak interest groups have to have an active part in the debate and make their issues visible given these conditions? And how can controversial scientific opinions and tentative scientific ideas then be included in exhibitions and SCTs.

According to Macdonald (1998) there seem to be a trend towards homogenisation of exhibitions, where it is difficult to put specific demands. This is also explicit in this study, where one respondent argues that it is difficult to display controversial issues, while being dependent on external financing. Such a trend risks leading to a cultural lessening, where minority interests will find it increasingly hard to get financial support in a competitive market. This means that when governmental support recedes, there is an increasing reliance on benevolence from others.

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APPENDIX I

Enkätgeneratorn Adam

Science Centers

Svarstabell: Svar

2007-10-02 11:30:08 (deadline 2009-05-27)

Du har **120** minuter att fylla i enkäten och spara resultatet

Syftet med studien är att undersöka vad svenska science centers presenterar i utställningarna. Med den senaste utställningen menar jag om ni haft någon tillfälling utställning på ditt science center. Har ni inte det ber jag dig relatera till den del av utställningen ni senast byggde upp/förändrade.

När du är färdig med enkäten klickar du på spara svar sist i enkäten. Du behöver inte besvara hela enkäten på en gång utan kan återkomma genom att logga in vid ett senare tillfälle. Glöm bara inte att spara svaren. Tack för din medverkan!

Värdera i vilken utsträckning du instämmer med följande påståenden: (Appreciate in what extent you agree with the following statements:)

1: Alla människor behöver kunskap om naturvetenskapliga begrepp och fenomen (All people need knowledge of scientific concepts and phenomenon)	Inget svar	Instämmer inte alls (Totally disagree)						Instämmer helt (Totallly agree)
2: Alla människor behöver kunskaper om hur vetenskapen tar fram ny kunskap (All people need knowledge about how new scientific knowledge is generated)	Inget svar	Instämmer inte alls						Instämmer helt
3: Naturvetenskap har lösningar på alla problem (Science has the solution of all problems)	Inget svar	Instämmer inte alls						Instämmer helt
4: Naturvetenskapliga förklaringar är definitiva. (Scientific explanations are definite)	Inget svar	Instämmmer inte alls						Instämmer helt
5: Forskare håller alltid med varandra. (Researchers always agree with each other)	Inget svar	Instämmer inte alls						Instämmer helt
6: Forskare för tydligt ut sina resultat till vanliga människor. (Researchers clearly communicate their results to ordinary people.)	Inget svar	Instämmer inte alls						Instämmer helt
7: Beslut i naturvetenskaplig forskning involverar etiska beslut. (Decisions i scientific reserach involve ethical decisions.)	Inget svar	Instämmer inte alls						Instämmer helt

8: Naturvetenskap hjälper mig att förstå vardagliga problem. (Science helps me understand everydag problems)	Inget svar	Instämmer inte alls						Instämmer helt
9: Forskare testar teorier hela tiden för att förbättra dem. (Researchers keep testing theories to improve them)	Inget svar	Instämmer inte alls						Instämmer helt
10: Naturvetenskap är en del av vår kultur. (Science is a part of our culture)	Inget svar	Instämmer inte alls						Instämmer helt
11: Naturvetenskap har sin egen kultur. (Science has its own culture)	Inget svar	Instämmer inte alls						Instämmer helt
12: Naturvetenskap är fri från värderingar (Science is free from values)	Inget svar	Instämmer inte alls						Instämmer helt
13: Naturvetenskap handlar om känslor och upplevelser (Science is about feelings and experiences)	Inget svar	Instämmer inte alls						Instämmer helt
14: Naturvetenskap är opersonlig. (Science is impersonal)	Inget svar	Instämmer inte alls						Instämmer helt

I vilken utsträckning tycker du att den senaste utställningen berörde: (In what extent do you think the latest exhibition dealt with:)

15: naturvetenskapliga fakta? (Scientific facts?)	Inget svar	I mycket LÅG utsträckning. In a very LOW extent						I mycket HÖG utsträckning. In a very HIGH extent
16: Naturvetenskap i samhället? (Science in society?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
17: Upplevelser av vardagliga fenomen? (Experiences of everyday phenomenons?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
18: Genus-aspekter? (Gener issues?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
19: vetenskap från andra kulturer än vår egen? (Science from other cultures than our own?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
20: Kontroversiella ämnen? (Controversal issues?)	Inget svar	I mycket låg utsträckning						I mycket HÖG utsträckning
21: Hur modern								

naturvetenskap växer fram? (How modern science is generated?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
22: Samhällerliga värderingar? (Values in society?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
23: Naturvetenskap i ett historiskt perspektiv? (Science in a historical perspective?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
24: Naturvetenskap i ett tekniskt perspektiv? (Science in a technical perspective?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning

I vilken utsträckning skulle du vilja att framtida utställningar berörde: (In what extent would you like future exhibits to deal with:)

25: Naturvetenskapliga fakta? (Scientific facts?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
26: Naturvetenskap i samhället? (Science in society?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
27: Upplevelser av vardagliga fenomen? (Experiences of everyday phenomenons?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
28: Genus-aspekter? (Gender issues?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
29: Vetenskap från andra kulturer än vår egen? (Science from other cultures than our own?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
30: Kontroversiella ämnen? (Controversal issues?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
31: Hur modern naturvetenskap växer fram? (How modern science is generated?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
32: Samhällerliga värderingar? (Values in society?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning
33: Naturvetenskap i ett historiskt perspektiv? (Science in a historical perspective?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning

34: Naturvetenskap i ett tekniskt perspektiv? (Science in a technical perspective?)	Inget svar	I mycket LÅG utsträckning						I mycket HÖG utsträckning

Sponsorer (Sponsors)

35: Fanns det sponsorer till er senaste utställning? (Where there sponsors sponsering your latest exhibition?)

- 0 Inget svar
- 1 Ja, Yes
- 2 Nej, No

36: På vilket sätt var de involverade? (In what ways where they involved?)

Välj ett eller flera alternativ:

- 1 Sponsorerna bidrog med pengar (The sponsors contributed with money)
- 2 Sponsorerna bidrog med material (The sponsors contributed with material)
- 3 Sponsorerna bidrog med kunskap. (The sponsors contributed with knowledge)
- 4 Annat. (Other)

Kommentar:

37: På vilka sätt påverkade sponsorerna utställningen? (In what ways did the sponsors affect the exhibition?)

Välj ett eller flera alternativ:

- 1 De hade synpunkter på vad som skulle visas (They had opinions about What to show)
- 2 De hade synpunkter på hur något skulle visas (They had opinions about How to show things)
- 3 De ville lyfta fram sin profil (They wanted to show their profile)
- 4 De påverkade inte utställningen (They did not affect the exhibition)

Kommentar:

38: Vilket utbyte hade sponsorerna? (What exchange did the sponsors have?)

- 0 Inget svar
- 1 Reklam (Publicity)
- 2 Inget utbyte (No exchange)
- 3 Annat (Other)

Kommentar:

Bakgrund (Background)

39: Jag är (I am)

- (•) 0 Inget svar
- ( ) 1 Kvinna (female)
- ( ) 2 Man (male)

40: Vilken inriktning har du i din grundläggande utbildning? Välj det alternativ som passar bäst. (What alignment do you have in your education? Choose the alternative that suits best.)

- (•) 0 Inget svar
- ( ) 1 Naturvetenskaplig eller teknisk (Scientific or technological)
- ( ) 2 Samhällsvetenskaplig eller humanistisk (Social scientific or humanistic)
- ( ) 3 Media eller konst (Media or art)
- ( ) 4 Pedagogisk (Pedagogic)
- ( ) 5 Utbildning inriktad mot museer (education within museums)
- ( ) 6 Annan (Other)

Kommentar:

41: Beskriv kortfattat dina huvudsakliga arbetsuppgifter på science centrat?

42: Hur många besökare har science centrat per år? (How many visit the science center per year?)

- (•) 0 Inget svar
- ( ) 1 mindre än (less than) 20 000
- ( ) 2 20 000 - 50 000
- ( ) 3 50 000 - 80 000
- ( ) 4 80 000 - 110 000
- ( ) 5 fler än (more than) 110 000

43: Vilken är verksamhetens huvudsakliga inkomstkälla? (Which is the science center's main income?)

- (•) 0 Inget svar
- ( ) 1 Statliga bidrag (goverment subsudies)
- ( ) 2 Kommunala bidrag (municipal subsudies)
- ( ) 3 Sponsorer (sponsors)
- ( ) 4 Biljettintäkter (ticket income)
- ( ) 5 Annan (other)

Kommentar:

44: Beskriv kortfattat science centrats officiella profil eller inriktning. (Describe shortly the official profile or alignment of the science center.)

Spara svar Återställ

startsida | visa resultat | summering av resultat | besvara | lista frågor | dokumentation och underhåll

Enkätgeneratorn Adam
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APPENDIX II

Interview guide

1. Background. Describe what I do, anonymity – impossible to identify.
2. What working assignments do you have?
3. What different professions are reptresented in the group which plan the exhibitions?
4. Describe in what ways the science centre is organised.

The content of the latest exhibition

5. What topic did the latest exhibition display? From what perspectives? How did you get the idea of displaying this?
6. What problems did you encounter when it came to describing the scientific content? In what ways did you prioritise? Add? Remove?
7. Was any part of the exhibition considered as more controversial when it comes to the scientific content? In what ways? Where there different opinions about this in the staff group? Did everyone agree?
8. Could you give me some examples of what different exhibits concern? In what ways is it possible for the visitors to recognise and understand scientific processes or how the scientific community has reached consensus? In what way is it possible for the visitors to recognise and understand that science is affected by society, politics and economy?

Generally about the content of the exhibitions

9. From where do you get the ideas about the exhibitions? From where do you acquire knowledge about the scientific content? Papers, universities, experts…?
10. Generally, when you plan exhibitions, have you experienced differences of opinions about what scientific content should be included? What have these differences concerned? How did you experience that? What opinions were represented? How did you solve the problems?

11. How do you handle differences of opinions concerning the scientific content? What or who decides what is acceptable to display? Is it possible to display non-consensus science?
12. How do you choose the scientific content for a contemporary exhibition? How do you handle two different explanatory models? Do you avoid such areas?

Communicating science in the latest exhibition

13. What aims did you have concerning the content of your latest exhibition? What messages did you want to communicate? In what ways do you think you succeeded/not succeeded? Give examples!
14. What did you want the visitors to learn? Do you have an idea about how this succeeded? Where there differences of opinions about how to communicate with the visitors? What?
15. From where do you acquire knowledge about visitors' learning?

Generally about communicating science

16. How do you think learning arises when visitors interact with your exhibits?
17. What theories about learning do you consider when you plan exhibitions?
18. In what ways do you evaluate visitors' understanding about your exhibitions? About science? About their learning from your exhibitions?
19. What strategies do you use in order strengthen your communication with the visitors?

APPENDIX III

Questions for focus group interview at an STC April 2007

- What factors do you believe affect/govern the scientific content in the exhibitions?
    - Are there more important factors than others?
    - In what ways do these factors affect the content? Examples?
    - To what extent is the content affected by what you have seen in other exhibitions? Examples?
- In what ways do you believe that economical aspects affect the content of the exhibitions?
    - Do you choose not to display aspects, which you would like to display, because of you do not think this will be very popular? Examples?
    - Do you sometimes choose to add aspects because you know that they are popular?
    - Have you experienced that sponsors have interfered concerning the scientific content? Examples?
    - Have you experienced that sponsors expressed that they do not want you to display something which you thought of? Examples?
    - Have you experienced that sponsors want to be visible in the exhibition? How do you handle that? Examples?
    - If you were not dependent on sponsors, would the exhibitions be different when it comes to the content? How?

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