HÖGSKOLAN Dalarna

Master Thesis in Science Communication

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Navet's Boxes
– an Evaluation of the Post-Visit Loan Service at a Science Centre in Borås

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Contents

Abstract

Many pedagogues believe science centres to be a good complement to the more formal school teaching. For a visit to a science centre to be as educational as possible, there is a need for pre-visit information of some sort, a guided visit, and post-visit work. Many science centres offer loan services of different kinds. At Navet, a science centre in Borås, teachers can borrow boxes with experiments connected to the different themes they provide. The experiments are supposed to be a continuation of the visit and help settle the knowledge gained during the visit.

This thesis is an evaluation of how the boxes function in the schools, and what the teachers think of them. The study was conducted through questionnaires and interviews with both teachers and the staff at Navet. The results of the study are very positive. Many teachers have been involved with Navet from the very beginning and they see a visit to Navet as an integrated part of their teaching. Some boxes work better than others and some might need clearer information, but overall the teachers see the boxes as timesavers, as a way to vary their teaching more easily, and as a help for teachers not specialized in mathematics and science.

Keywords: science centre, informal and formal teaching, loan services, summative evaluation, pedagogical dramatization, stationary experiments, questionnaires, interviews.

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1. Science Centres and Pedagogy

In this chapter the history, definition, activities and educational programmes of science centres will be presented. This chapter also contains arguments for the importance of science studies and the role science centres can and do play in our society, and the pedagogy attached to it.

1.1 Science Centre History

Science centres are *exhibition and activity centres with the purpose of popularising science and that strives to learning through interactive objects and demonstrations*. NSCF = Nordisk Science Center Forbund, http://www.nordicscience.org/indexsv.htm

In *The Museum Experience*, Falk & Dierking (1992) define museums as *historical homes and sites; science and technology centers; aquaria, zoos, and botanical gardens; as well as the traditional art, history, and natural history museums*. Museums were from the beginning just about collections and research, but have now become more of institutions for public learning, and also viewed by the public as such.

Science centres, or science areas, do not have to be confined to a building. Aadu Ott (2000) mentions that one can also use a whole city to combine a display of both technology, history and culture. One can also make use of recreation areas to build exhibits.

According to Salmi (1993): *A science centre is located […] where science, technology and education all meet*. In other words, a science centre should combine the features of these three. Some science centres only deal with natural and physical sciences, but they can also include humanities, history, psychology, social sciences and linguistics. By including the other sciences as well, science centres can get visitors that are not too familiar with natural sciences, but need a wider perspective to understand the place of science in their lives.

A science centre's agenda is, in general, based on the principle of empiric scientific method; the visitors should be able to touch and experiment on their own to find out how things work. Francis Bacon (b 1561 - d 1626) was one of the first developers of the empiric scientific method –and the oldest plan for a science centre can be found in his writings. He made a proposal for a museum of discoveries and a gallery of the portraits of great inventors, and the spirit of empiricism is there to be found. The purpose of this centre was to show the public the importance of mechanics and sciences, and in doing this, Bacon wanted to combine the worlds of art and science. René Descartes (b 1596 – d 1650) also made a proposal for a museum that, unfortunately, was not realised. The plan was to present scientific instruments and mechanical models. The establishment of one of the first science museums: the Conservatoire des Arts et Métiers in Paris in 1794, can be derived from Descartes writings and plans, that had fortunately survived for over a century (Salmi 1993).

Aadu Ott (2000) points out that one of the reasons why the Conservatoire des Arts et Métieres was founded, was that the French Revolution led to a will of the people to get more educated. This museum then served as a model for three later science museums: Science Museum in London, Deutsches Museum in Munich and the Palais de la Decouvert in Paris. These, in their turn, inspired to the Technical Museum in Stockholm. The Deutsches Museum, or the Deutsches Museum für Meisterwerke in Wissenschaft und Teknik as it was called at first, was built to glorify German technology and German science. But it was also a place for gifted, but poor, young people to read scientific literature and study technological devices. In that way, those who couldn't afford to study at the university got a chance to educate themselves. The museum was thus typically hands-on and meant to display technological progress and spread knowledge.

Gottfried Leibniz's (b 1646 – d 1716) idea went many steps further. His plan for a science exhibition could be something thought of today. He wanted not only to demonstrate scientific phenomena to the public, but also educate them and make them enjoy the show. Leibniz included many practical examples of this: the Magic Lantern, optical illusions, large-scale globe models, muscles, bones and nerves etc. Another revolutionary thing with Leibniz's idea is the fact that he intended the exhibition to be for children and, furthermore, to be used 'hands-on' by them. Three hundred years before the first modern science centres, Leibniz outlined the educational principles of them. In 1768, The American Society for Promoting and Propagating Useful Knowledge was founded, as a result of Benjamin Franklins (b 1706 – d 1790) work. He too emphasised the popularisation of science using models and exhibitions. The Swedish engineer and inventor Christian Polhem (b 1661- d 1752), who designed hydraulic elevators for the mines of Falun and planned the Svea channel, wanted to open an exhibition of technology and machines. The exhibition was to be linked to his laboratory. Unfortunately it did not become a reality, but the models that were donated, became the Royal Model Chamber exhibition a few years after Polhem's death (Salmi 1993).

In addition to prominent and open-minded scientists, the roots of science museums are also to be found in the numerous exhibition cases of the 17th and 18th centuries. Often these exhibitions were collections of technical and scientific models, owned by upper class people. In many countries, the museums' aims have been to present their country's glorious history and art with the portraits of its monarchs, and so, royal families and wealthy rulers have played an important part of the foundation of museums (Salmi 1993, Hein 2002). Also Bennet (1995) points out that these collections have not always been open to a broader public. The collections (whether of works of art, curiosities or objects of scientific interest) have, during the ages, gone under a variety of names (museums, studioli, cabinets des curieux, Wunderkammern, Kunstkammern) and have had a variety of functions (demonstrations of royal power, symbols of aristocratic or mercantile status, instruments of learning). For some time they all constituted socially enclosed spaces to which access was remarkably restricted. So much so that, in the most extreme cases, access was available to only one person: the ruler. In the late 18th and early 19th centuries these collections dispersed and were placed in contexts less enclosed.

In Britain, the development of popularisation of science took a different path. During the 18th century, scientists and inventors travelled the country giving lectures. These lectures were, although part of the formal university teaching, quite lively. Soon they became a recurrent part of all kinds of popular gatherings and fairs. When the lectures left the universities, the demonstrations became even livelier, for example by means of models, motors, air and hydraulic pumps etc. In an industrialised society, the public wants to know about the progress

made and how great their society is in comparison to the earlier stages (Salmi 1993). Science and industry reshaped people's lives and through urbanisation and governments taking over some responsibility for education, museums became institutions that could educate the masses (Hein 2002). This spirit gave birth to the Great World Expositions, which presented the latest technical and industrial achievements. The presentations of the scientific progress were often supported by means of art and with a great sense of nationalism. For example, Deutsches Museum in Munich has its roots in the Great Exhibitions. Still in the 1980s and 1990s halls and exhibits originally made for the world expos are used by science centres (Salmi 1993).

Tim Caulton (1999) sees two, more recent, origins for the modern hands-on museums and science centres; the first children's museums in late 19th century USA, and major traditional science museums in early 20th century Europe and North America. It is not hard to see forbearers to interactive exhibits in the industrial engines at the Deutsches Museum, chemical demonstrations at the Palais de la Découverte, simulated coalmine at the Chicago Museum of science and Industry and a walk-through beating heart at the Franklin Institute in Philadelphia. The Children's Gallery at the Science Museum in London, which opened in 1931, is one of the first science centres. It was originally planned to be an introduction to the museum, but the younger visitors found it so interesting, with its working models and dioramas, that it soon became a part of its own.

The Deutsches Museum and the Childrens' Gallery inspired Frank Oppenheimer, and in 1969 he opened the Exploratorium in San Francisco. It was a completely new kind of institution with a truly hands-on approach, and it is still one of the best science centres in the world. Its founding made way for several more science centres in North America. Through the Exploratorium, other science centres, or science centres to be, can get "cook books" that helps them get better or get started with well proven exhibits (Caulton 1999). According to Ian Simmons (1996) hands-on science, as we know it today, originated from the Exploratorium.

Museums thus originate from private collections not open to the public, and the collections have always been the most important parts of the museum. But this approach does not work as well in an age of mass-communication media, where the attention span of youths is said to be shortened by the steady stream of image bombardment. So the museums must change, or risk losing their audience to entertainment parks for example. One way of doing this is to use entertainment as a stepping-stone to education. For learning to occur, the visitor must be open minded and have fun, and by the use of drama, interaction and play, the visit to a museum or science centre becomes more enjoyable, and visitors will remember better (Roberts 1997).

The Western economies have become more 'entertainment-based' than before. Consumers are always looking for goods or places that can give them a lot of fun for their money, even in areas that used to be work- and chore-related. Science centres have made some museums rethink their more traditional ways of displaying, with their more lively and engaging exhibitions of science. There is a risk though, that the content of an exhibition falls in the background to make way for interactivity, which does not make a good exhibition (Hughes 2001). Museum visitors in our mass-media society are no longer satisfied with simply looking at dioramas and reading texts. They lose interest quickly and want to be actively engaged in the exhibits, and even more important - be entertained while learning (Caulton 1999).

Science centres are not only about exhibits and experiments. They can also offer training and courses for teachers, libraries, loan services, out-reach programmes etc. They are not only about teaching, but just as important is their function of making people more motivated to

learn, more interested in science and more courageous in trying to understand things that might seem too difficult (Hooper-Greenhill 1994).

1.2 Why Study Science?

There are a number of reasons for studying science and many researchers and pedagogues believe that science and the understanding of science have to become a part of every person's normal day-to-day life, not just something that is studied in school and then forgotten. Coombs (1993) says that: *The aim is not solely to produce more scientists and technologists; it is also to produce a new generation of citizens who are scientifically literate and thus better prepared to function in a world that is increasingly influenced by science and technology*.

In pursuing this aim, new forms of education are actively sought. For example, informal, out-of-school programmes at museums and science centres used, and co-operations between formal and informal educational institutions are becoming more and more common. For someone to learn, and not just remember, the facts need a meaningful context. The context can be made meaningful in several ways. For proper learning to occur, the topic must become relevant to the learner and have a place in the life of the learner. The process of learning must also be structured so that the learner can fully understand the topic (Salmi 1993).

Svein Sjøberg (2000) presents four arguments for studying science in our society:

- Economics – science studies can get us better jobs; and a country with highly educated inhabitants is considered a high-status country.
- Usefulness – science helps to understand our world and things in it.
- Democracy – it is important to understand difficult questions for example when voting in a referendum.
- Culture – science is irrevocably a part of our culture.

The English researcher Lucas (in Ott 2000, p 10) has an opinion very similar to Sjøberg's:
One of the justifications often given for science education is the production of a scientifically literate public. An analysis of "scientific literacy" shows three types:
***Practical scientific literacy**. This has that kind of scientific and technical knowledge that can be put to immediate help to solve practical problems.*
***Civic scientific literacy**. This is "to enable the citizen to become more aware of science and science related issues so that he and his representatives can bring common sense to bear upon those issues." An example is the direct public participation in decisions about nuclear power.*
***Cultural scientific literacy**. This is "motivated by a desire to know something about science as a major human achievement."*

Even though science is a part of our society, there is a need for more education. But maybe it isn't education <u>in</u> science that is needed, but education <u>about</u> science; putting science in a context, historically and philosophically, to get people to understand the place science has in their everyday lives. This is where Public Understanding of Science and Technology, PUST, enters (Ott 2000). One project that deals with PUST and how to increase the interest in science and technology is the NOT-project (Naturvetenskap och Teknik = Science and Technology) that ran between 1998 and 2003, with Lotta Johansson as one of the members.
http://www.skolutveckling.se/utvecklingsteman/naturvetenskap_teknik/not.shtml

There are many different projects that deal with PUST. It seems formal educational systems have, in many cases, failed to educate all citizens to become literate in science and technology. One reason for this might be that schools usually offer pupils the products of science, but not the means to develop their own products, and think more freely for themselves. Science lessons are often teacher-directed and close-ended, too abstract and often seem to lack relevance for the pupils' everyday lives. (Bencze & Lemelin 2001) Museums can serve as a complement to the formal education in schools and provide teachers and pupils with services that schools are unable to manage, for different reasons; lack of resources, personnel, money etc (Axelsson 1997, Bencze & Lemelin 2001).

1.3 Science Centre Pedagogy

Objects should be brought into his proximity. […] From this, the golden rule for teachers follows: everything shall, as much as possible, be shown to the senses. If something can be comprehended by several senses at the same time, it should be presented to them simultaneously. […] This demonstration through the senses will lead to lasting knowledge. […] If sometimes objects are missing, they can be replaced with material produced with a pedagogical purpose. Comenius (1989)

Aristotle (b 384 BC – d 322 BC) (in Bagge 2003, p 11) claimed, already in the 3rd century BC, that: *All teaching and all intellectual learning come about from already existing knowledge*. This is a thought that for example Hein (2002) has incorporated in his constructivism. Comenius (b 1592 – d 1670) (1989) thought, like so many both before and after him, that education should be graphic and adapted to the pupil's age and maturity, and go from the general to the specific, from the known to the unknown. Education should also take in account for the whole world around us. Comenius also thought that women should get an education, an opinion not very common in the 17th century. Even before Comenius, Thomas Aquinas (b 1225 – d 1274) stated that we should learn things by using our senses, since that is where knowledge has its beginning. (Hooper-Greenhill 1994) A more recent spokesman for this "adapted learning" is David Ausubel. All learning must start on the same level as the pupil. A pedagogue must find out on what level the pupil is, and teach from there. (Ausubel 1968, Sjöberg 2000) Ausubel (1968) also points out that discovery learning is important to make abstract concepts more concrete. A pupil might not understand without the experiment.

What we have to learn to do, we learn by doing (Aristotle, in Bagge 2003, p 45). *Teach by doing whenever you can, and only fall back on words when doing is out of the question*. (Jean-Jacques Rousseau (b 1712 - d 1778), in Bagge 2003, p 12). Maybe John Dewey had these classics in mind when he, in the beginning of the 20th century, developed the progressive pedagogy with the catchphrase *learning by doing* (Dewey 1998). Dewey believed that the school had to leave behind the outdated teachings and get the school to teach how to solve practical problems that can, and will, occur in our society. The strict division between theory and practice must be abandoned. Education should be adapted to the pupils' different levels of knowledge and creativity, and they must be taught things they can use in "real" life, i.e. outside school (Dewey 1998). John Dewey expressed it like this: *I think that a lot of the current education fails because it neglects this fundamental principle about the school as a form of social life. It perceives the school as a place where certain information is given, where certain homework is done or where certain habits are founded. The result is that this*

does not become a part of the child's experience of life and in that way not in the real sense educating. (Dewey 1998, translation from Swedish by Renée Göthberg).

Lev Vygotskij, a Russian psychologist also concerned with children's education, was like Dewey of the opinion that all education should be oriented towards the future development of the child. Knowledge has to be taught as part of a bigger whole. It can never be taken out of its context, or it will lose its meaning and the possibility to motivate. Education is also a socio-cultural process and the child is going forward through interaction with teachers, family or friends (Bråten 1998). Rosalind Driver (1983) believes that someone more competent should bring children into the world of science; by a process she calls *enculturation*.

Vygotskij (in Ott 2000, p 51) also talks about the zone of proximal development, ZPD. The ZPD can be described as two circles, where one is smaller and inside the other. The pupil can handle the inner circle by himself, and after a while get bored there. To reach the periphery of the outer circle he needs the help of a more competent person. Outside of the circle it is too difficult and the pupil gets frustrated. The most effective learning occurs between the circles, where pupil and teacher co-operate. Another Russian psychologist, Luria, has created the concept of *appropriation*. According to Luria, children cannot construct relevant knowledge on their own. They need someone more competent to support them. This means that a science centre needs competent staff with real subject knowledge.

Jean Piaget studied the development of children. He came to the conclusion that children go through different stages of development, both physical and psychological, in the course of growing up, and the stages occur at specific ages. The critique against Piaget, is mainly about that he doesn't account for individual differences and the stages are very strict in their division (Beard 1970). Travers et. al. (1993) believe that the stages are overlapping; one does not exclude another. Sometimes a child's level of cognitive development seems to depend more on the nature of the task rather than on a rigid classification. Another criticism is that this theory is only applicable on western cultures. The idea that children undergo these developmental stages is not criticized however, (Beard 1970) or the notion that educational material has to be adapted to the child's level of maturity. One way of using Piaget's theories is to disregard the specific ages, but still see human development as one stage after another. A prodigy develops a lot faster than other children, but the development still follows the same path (Gardner 1994). Despite the criticism, Piaget's theories are important because they show that children have different needs in different parts of their lives, and we learn by constant problem-solving interaction with our environment (Caulton 1999). Part of these stages includes interaction with peers as a development of the child's maturity. Piaget also wrote about processes for learning. The two main processes are *adaptation* to the environment and *organization* of experiences through mental activity (Beard 1970). *Each time one prematurely teaches a child something that he could have discovered for himself, that child is kept from inventing it and consequently from understanding it completely.* (Piaget, in Säljö 2000, p 58)

Another often cited text is a Chinese proverb, often part of the educational thesis of science centres: *I hear – and forget. I see – and remember. I do – and understand*. Science centres use a lot of interactive means of teaching. The idea is that you learn better by doing, an idea that has existed maybe for as long as knowledge has. One of the earliest interactive medias is the pop-up book. Zethraeus (2004) writes that these books were used in the 14th century for scientific purposes. Some of us may think of these as entertaining children's books, but the fact is that they do have potency as books of fact, where you, among other things, can see the

planets' orbits around the sun, how a car engine works or the inside of Tutankhamon's sarcophagus.

According to Elsa Feher (1990) there are four steps a science centre visitor goes through for the learning to be effective. The visit has to start with *experiencing*. The next step is *exploring* the exhibits and what the science centre has to offer. Then the visitor tries to understand what is happening in the exhibits or experiments, to get an *explanation*. On the fourth step the visitor *expands* his knowledge and then, after the visit, it has to be made relevant and useful for the visitor's everyday life with a fifth step, *conceptualisation*.

Teaching is one of the museum's major goals. But in spite of this fact, Falk & Dierking (1992) say that museum staff has doubted that learning really occurs and unfortunately it is very difficult to prove that it does. One of the reasons for this is that there are so many different definitions of learning. When it comes to learning, there are many factors to consider. Personal, social and physical contexts matter as far as learning is concerned, but many theories don't take this into consideration.

Failure to distinguish among learning, education and schools causes confusion among the concepts of learning cognitive information (facts and concepts), learning affective information (attitudes, beliefs and feelings), and learning psychomotor information (how to center clay on a potter's wheel or focus a microscope). Learning, as defines by many theorists, focuses only on learning cognitive information. (Falk & Dierking 1992).

Schools and universities have no problems articulating their educational mission; they have very clear agendas and syllabi (Falk & Dierking 1992). For museums however, this is not as easy, which is a bit ironic since museums have always been centres of learning. Early American universities, for example, were organized around cabinets of natural history and art galleries.

Howard Gardner (1994) criticizes the narrow thinking of IQ and the tests connected to it. Human intellectual competence should include a number of tools for problem solving preparing for difficulties that can occur in our everyday lives. A human being must have necessary and valuable capacities to be able to be regarded as intelligent. IQ-tests only measure the "book intelligence". Gardner believes that humans have several different intellectual capacities, more or less disconnected from each other. These intelligences, or capacities, are; the logical-mathematical, the linguistic, the spatial, the musical, the bodily/kinaesthetic, the interpersonal, the intrapersonal, the naturalistic and the existential (Gardner 1994, 2001, Falk & Dierking 1992). If having these in mind, you can understand that people are different and furthermore they learn differently. The material in schools and science centres should therefore be adapted to fit all people and all intelligences. John M. Steinberg (1994) talks about three different learning styles or systems for receiving information: visual (learning by reading, looking at pictures or diagrams), auditory (learning by listening to lectures and stories) and kinaesthetic (learning by doing). We use all three systems when learning, but we usually have just one of them as a primary system.

During the 1980's Bernice McCarthy (1980) presented and developed the 4MAT-System that shows four learning styles and preferences for perceiving and processing information. These are: concrete experience (feeling), reflective observation (watching), abstract conceptualisation (thinking) and active experimentation (doing). In science centres you can hopefully combine all four to get a meaningful learning situation for all visitors. Gardner's theories of sev-

eral different intelligences are also something to have in mind while constructing exhibits and programs. Gardner and McCarthy are two researchers that take into account individual differences and learning styles in their models of learning.

Mihalyi Csikszentmihalyi and Eugene Rochberg-Halton (1981) have studied the role of internal motivation in the process of learning. There are three conditions for internal motivation to occur:

- the tasks must be equal to one's ability,
- there must be clear goals for what will be learned,
- there must be clear feed-back.

Without these conditions it would be very difficult to get people to concentrate on something just because it's there.

Most psychologists agree that learning is not something that occurs instantaneously. It is to store information over time and somehow process it. If it is not considered and worked over, it is not learned. (Falk & Dierking 1992) This is why one can assume that a visit to a science centre creates more knowledge if the visitors get both pre- and post-visit material to work with. Meaningful learning is according to David Ausubel with colleagues (Ausubel 1968, Falk & Dierking 1992, p 114) *[…] the linking of new information to existing concepts and principles in a learner's knowledge structure.* Successful lessons build upon already existing knowledge. It is therefore important for the school programs in museums and science centres to be designed with the schools' curricula in mind. Museums should also seek to make a connection to the everyday lives of their visitors. If such a connection exists, there is a high probability that visitors will remember and later use the knowledge acquired at the museum. Personal interaction also increases the likelihood that a museum visit becomes memorable. Museum staff can dress up or assume roles when presenting important concepts and ideas. It is also important to give attention to the visitors and make them feel important (Falk & Dierking 1992).

There are many different ways to learn, for example formally or informally. Schools first of all give formal education. Schools have strict syllabi, an obligation of attendance, grades etc. Informal education is given by institutions whose primary goals are not education; newspapers, libraries, hobbies etc (Hein 2002, Salmi 1993). According to Salmi, there is also another definition useful in this discussion; out-of-school education. This is a link between formal and informal learning and occurs outside the physical school building, but it still follows a curriculum (Salmi 1993).

Busque (1991) describes the difference between learning in school and learning in a museum as:

- *Population in a classroom is homogeneous, in a museum heterogeneous.*
- *Participation in a classroom is mandatory, in a museum voluntary.*
- *Activity in a classroom is closed, in a museum open.*
- *Goals in a classroom are evident, in a museum not always evident.*

A science centre is not a school, but a medium on its own, a medium for knowledge and experience. Dale et. al. (1997) divide the two media and their education like this: *Formal classroom lesson is "information-rich, experience-poor" in direct contrast to the experience in a science center or zoo, which is "information-poor, experience-rich.* And due to this dichotomy, the two media complement each other.

A science centre can never replace the education that is given in the formal school, but it can be a very useful complement. For a deeper understanding it is important for the schools to use the resources of a science centre repetitively and also have some post-visit work or discussions, because the whole cognitive process does not occur during the visit (Ott 2000). There are some disadvantages with classroom learning, for example lack of time, space and resources. A science centre on the other hand is filled with artefacts, exhibits and experiments that visitors can explore and tamper with. (Caulton 1999)

In *Upptäckarglädje! Om museipedagogik* (*The Joy of Discovery! On Museum Pedagogy*) (1999) Statens Kulturråd - The Swedish National Council for Cultural Affairs - talks about museums and their many different functions. The most important might be that museums function as a society's collective memory and thus a resource of education for the whole population. Museums also have a responsibility, along with other cultural institutions, to increase the participation of children and teenagers in the cultural life. The best way to reach this whole group is to go through schools and childcare. Museum pedagogy usually includes more exciting ways of communicating knowledge than the regular school. For the younger children it can be more games and for the older more problem solving tasks. Entertainment and education are not two conflicting phenomena. On the contrary, they can be very useful together, as long as they are properly balanced. Too many facts can be boring and too much play can become quite meaningless in educational purposes. According to Matti Bergström (1995), a Finnish neuro-researcher, children only learn things they find interesting and fun, the rest just does not stick. It is a classic "feed-back" loop (Falk & Dierking 1992) - you learn best what you are already interested in, and you are interested in things you learn easily.

Anyone who thinks education [learning, a mindful play] and entertainment [play, a mindless learning] are different doesn't know much about either. (Marshall McLuhan in Yahya 1996, p 144). Human beings use play in many different learning situations, even without thinking about it. For example it is very common to "play around" with new equipment to learn how they function, instead of reading the manual (Yahya 1996).

Visitors to a museum might not always bother to read the exhibit labels. Text can seem dry and a bit boring, especially for children. One way of getting the fact to seem more interesting and easier to relate to is to use live guides or actors. Drama and theatre are effective and cheap ways of getting the message across. It engages the visitors both emotionally and intellectually, and it takes advantage of the role social interaction plays in learning. (Hein 2002, Pearce 1996) […] *drama might just be the most effective way of ensuring that visits to science exhibitions actually stir the emotions and thus become memorable*. (Arnold 1996).

Kristina Svensson (2000) made a qualitative survey at the Swedish Museum of Natural History, for her dissertation regarding the role of drama activities in a museum. Many of the museum visitors, mostly younger ones, were very positive to having theatrical programmes in museums. They wanted something to make the museum more alive and it also gives the visitors a good opportunity for asking questions. Svensson believes that there is a potential for educational techniques using theatrical performances, as long as the performances are well planned and have a specific target group, so that they are on an appropriate level for the audience.

It is not only the way a science centre displays science that affects the visitors' learning possibilities. A science centre can have great pedagogues, a lively presentation and great exhibits, but they also have to take in account that it might be the visitor's first time at the science cen-

tre and is therefore distracted by the environment there. For a child to be able to concentrate and learn, it can be a good idea to first have some free time when they can familiarize themselves with the place, or at least some pre-visit material to prepare with (Falk & Dierking 1992).

1.4 Pre- and Post-visit Work

It is very easy to forget things that are read, heard or shown only once. For knowledge to really settle in the mind of the learner, repetition is crucial, just like the Latin proverb says: *Repetitio est mater studiorum* (Repetition is the mother of studies).

A science centre can act purely as a creator of interest, and nothing more. When schools visit science centres, there is often a more educational purpose as well. A visit to a science centre should be both fun and educational, but to get a valuable and instructive visit, both pre- and post visit work is needed. This puts a responsibility on the teacher, who needs to connect the regular schoolwork to the visit (Caulton 1999, Ott 2000, Wictorin 2001). Included in a visit to Navet are both a pre-visit assignment and a box with experiments to work with in school afterwards. This system makes it easier for teachers to connect the science centre-visit to their curriculum.

To increase the possibility of learning from museums, science centres etc, pre-visit lessons have shown to have a positive effect. This is because the pupils hear of the same things twice, but in different situations and through different media. Materials for these pre-visit lessons are handed out from many science centres that have programmes of schools visits. The material can be of different types; from experiments to general information about the science centre and the upcoming visit. The pre-visit material helps the pupils to learn and the teacher to plan the visit thoroughly (Falk & Dierking 1992, Salmi 1993) The positive effect of pre-visit material has been studied since the 1930s by for example Melton, Feldman & Mason in 1936, Davis & Kimche in 1976, Koran & Baker in 1978, Gennaro in 1981, and Danilov in 1982. To complete a visit to a science centre and to reinforce the learning that hopefully occurs or begins during a visit, there should also be a post-visit work in school (Salmi 1993).

In a study from the University of Oslo, Merethe Frøyland (2002) presents the Extended Classroom Model (ECM). The ECM functions as a bridge between the formal learning in schools and the informal learning in museums or out in nature. First the pupils get the basic facts during a lesson in the classroom. Then the new knowledge gets a cultural setting in a museum, or science centre, and finally the knowledge is deepened in a natural setting where the pupils get to use their knowledge in a practical way. Frøyland's study shows that the pupils get better results and a greater understanding of a topic when the activities in the classroom is connected with a visit to the museum or, when it comes to geology lessons as studied by Frøyland, a proper mine for example. With this mode of teaching the pupils get facts and information during several different occasions, in several different ways. Frøyland discusses Howard Gardner's theory of Multiple Intelligences (MI) as useful in teaching and a varied learning environment helps with reaching different types of learners. The schools can't give a person all the knowledge needed. When it comes to lifelong learning, the museums play a big part, and this is one reason for schools and museums to cooperate.

Bitgood (1991) have a suggestion for nine activities that should be conducted together with a visit to make it as worthwhile as possible:

- Integrate the visit in the curriculum
- Evaluate the pupils' interest, ability and experience before the visit.
- Prepare for the visit by explaining schedule and environment.
- Prepare for the visit with relevant exercises.
- Use the visit as an opportunity to collect experience and memories instead of facts.
- Form the activities so the environment and the possibilities given there are fully used.
- Evaluate the pupils' reactions after the visit in purpose of better future visits.
- Enhance the experiences by activities in the classroom.
- Plan everything in detail to eliminate discipline problems.

By following these recommendations, or using one's own, teachers can in many ways affect the value of a science centre visit. For a science centre to fill an educational purpose, Axelsson believes there must be a co-operation between formal and informal learning, schools and science centres. It is also important that schools not just visit once and never again. It takes time for pupils to gather knowledge, understand scientific relations and phenomena. In the research Axelsson has made, she discovered that not all teachers prepare the visit, but almost everyone wanted some sort of post-visit work to be done. And there is a will to incorporate science centre visits into the schools curriculum (Axelsson 1997).

1.5 Loan Services

When museums became more public and run by civic authorities, schools began to make use of them and the educational role of the museums formalized. Museums have been an educational resource for a long time, and being able to borrow artefacts and experiments has been a service since the end of the 19th century. Liverpool, Sheffield and the Ancoats Art Museum in Manchester were among the first provincial museums to offer this help to schools in the area (Hooper-Greenhill 1994).

Today, loan services from museums and science centres are a widespread possibility for teachers. With its help they can offer their pupils lessons with more variation and maybe even more fun. Teachers usually have a very tight schedule and not much time to think of new things to do with their pupils. In the lower grades of school, many teachers don't even have science in their education, so they need all the help they can get in making good science lessons.

In Sweden there are many science centres and other institutions that offer some kind of loan services. Boxes with material for schools to work with are not specific for Navet. Falun Future Tech (http://www.falunfuturetech.se) had their own boxes before as well, but now they are a part of a project called Science and Technology for all (Naturvetenskap och teknik för alla, NTA, http://www.nta.nu). This is a co-operation between The Royal Swedish Academy of Science, The Royal Swedish Academy of Engineering Sciences and schools around Sweden. From NTA, schools can borrow boxes with a specific theme to work with in the classroom. Many schools don't have the money to buy material for experiments for example, but this project is a way of giving the schools the opportunity to work a bit differently within the curriculum.

NTA has loan services for 14 different themes in biology, chemistry, physics and technology. The themes include text material for both teachers and pupils, laboratory material and theme-education for the teachers. Every theme takes about 10 weeks to work with and they are ac-

cording to the school syllabus but do not cover every aim. NTA's aims are to awaken an interest in science and technology and to educate and develop both teachers and pupils.

From Framtidsmuseet in Borlänge, schools can borrow boxes and book pedagogues to come to the school. The boxes include laboratory material, and the purpose with the boxes is to make science and technology fun, tangible and interesting. http://www.framtidsmuseet.se

Many science centres work with a three-part visit; pre-visit assignment, the actual visit and post-visit work (for example Molekylverksta'n in Stenungsund, http://www.molekylverkstan.com). The post-visit work may consist of boxes with experiments or just a pamphlet with instructions for further work. Some science centres are a part of NTA and has therefore a loan service with those boxes (for example Fenomenmagasinet in Linköping, http://www.liu.se/fenomen/). Science centres without any loan services usually have books, pamphlets or files on their website, with instructions to experiments the classes can work with in school (for example Technicus in Härnösand, http://www.technichus.se/, Teknikens Hus in Luleå, http://www.teknikenshus.se, Tekniska Museet in Stockholm, http://www.tekniskamuseet.se). (Material from the Internet was gathered 04.06.01)

1.6 Navet

Navet is one of the science centres in Sweden that offer different kinds of loan services to teachers and others in need of them. The name, Navet, has a double meaning. The name both connotes to natural science (**na**tur**vet**enskap) and the science centre being the hub (navet) between science, technology and the schools. The boxes at Navet are most often used as post-visit work, but can also be borrowed for other occasions and disconnected from a visit. The information about Navet is taken from the annual report by Lotta Johansson and the description of a visit to Navet is from my own observations and conversations with the staff.

Navet is since 1996 the science centre for Sjuhäradsbygden, an area around the city of Borås. Their mission is to encourage the public's interest for technology, natural sciences and mathematics. Navet also helps school staff with in-service training and support them in developing pedagogical methods and materials for the classrooms.

Navet's vision is to make the meetings with science and technology joyful, inspiring and contextual, so that the public dares to and wants to engage in questions in these areas.

Navet's aim is to help develop Sjuhäradsbygden to become an attractive and competitive region with a high educational level and a population with a big interest in technology, science and mathematics. One way of reaching their goals is their work with school classes and teachers.

Navet's motto is *You and science*. Navet wants to give knowledge and create an interest in science, technology and mathematics by having interactive exhibits and exciting pedagogy. Navet emphasizes the meeting more than the materials and exhibits, both the meeting between people and the meeting between people and science. Teachers that use Navet should feel that it gives them possibilities to develop their teaching methods. In Navet's cooperation with the educational system, the focus should be on the schools, not on Navet. Navet should give inspiration and ideas for the schools to keep working with.

At present, Navet has about 2 500 m^2 of exhibition area and ten different themes to work with.

Navet's ambition is to catch everyone. The most important things are the meeting between people and the awakening of an interest. It is very important that people learn that they can understand math and science. From the beginning the most important thing was to capture the teachers that didn't have a lot of interest or education in math and science, for example quite common among middle-aged female teachers. If Navet could get those teachers to borrow a box and continue the work at school, they would reach a lot of other people as well. The personnel at Navet are former teachers, regular people. The visiting teachers should feel like they can do the same thing with their classes in school, that the pedagogues at Navet are doing during a visit.

1.6.1 Navet's Themes

Navet's themes are adapted for different age groups and some of them can also be presented in English. The school groups that visit Navet range from pre-school children that are 4 years old to adult immigrants that are studying Swedish. Navet also has visits from university students and corporate companies.

Themes for the semesters of spring and autumn 2004:

- Air & aviation
- Astronomy
- Biotechnics
- Chemistry for the youngest
- Crime lab
- Energy
- Light
- Mathematics
- Water, 2 different levels

Examples of older themes:

- Benny (sceleton)
- Digestiva (digestive process)

Not all themes have boxes yet, but the goal is to be able to offer loan services connected to every theme. During the period of this study there were seven boxes available; Chemistry, Energy, Light (2 boxes), Mathematics, Space and Water.

The themes, and the boxes connected to them, are planned so they correspond to parts of the school curriculum. The school curriculum in Sweden is quite flexible. The school's mission, according to Lpo 94 (1998), the current curriculum, is to promote learning and teach the pupils to actively seek information and knowledge. The pupils should learn to be critical when reviewing facts and they should be taught about actions and consequences. When it comes to mathematics, the pupils should master basic mathematical thinking and be able to use it in everyday life. They should also know about and understand the basic concepts and contexts of natural science and technology. The goals stated in Lpo 94 are, to an extent, covered through visits to Navet and the loan services offered by Navet.

1.6.2 A Visit to Navet

The pedagogy at Navet is quite special, both due to the environment and to the organisation of the visits. Navet is placed in an area famous for their textile industry, and as many things as possible at Navet are constructed of different fabrics. This, and that the different themes are inspired by different time periods and cultures, make the environment more appealing to visitors that might not have the greatest interest in math and science, but instead maybe the humanities. Both the environment and the pedagogy at Navet aim at being appealing to different people with different interests and different ways of acquiring information and knowledge. The pedagogues at Navet are inspired by for example Howard Gardner and his multiple intelligences and Steinberg and the different learning styles. Francis Bacon wanted to combine the worlds of art and science in his gallery of discovery, so also his spirit can be found in Borås. As stated before, according to Vygotskij, knowledge cannot be taken out of its natural context, but it has to be shown as a part of the bigger whole. This is what Navet does when they place their experiments in a time and place where they can be understood in a context. In this way the visitors also get an understanding of what place in their lives math, science and technology hold. Dale et. al., as stated earlier, claim there is a dichotomy between schools and science centres, but in the way the pedagogues at Navet work, a visit there is both “information-rich” and “experience-rich”.

The primary target group for Navet is school children. Navet is only open to the public on weekends and holidays. For the school children, a visit to Navet is not only a one-hour and a half-stay at a science centre. It consists of a pre-visit assignment, the proper visit and then post-visit work in the classroom. The pre-visit assignment is to get the children thinking about the theme or subject they are going to visit and to prepare them a bit for it. In that way the subject is not a total surprise and they can concentrate better. The assignment usually consists of something they make and then bring to Navet where it is being put up somewhere in the house. Every group has chosen a theme for the visit. There are ten different to choose from, and every theme has a specific part of the house. The themes are all inspired by different cultures. The pedagogues that work with the group are all dressed up as scientists, mathematicians or other characters connected to the theme and every visit starts with a dramatization. After the introduction the group experiments on their own and the staff is always available for questions or help in other ways. When the visit is over, the classes can borrow boxes with experiments, games, books etc, to continue the work back in their school.

2. Aim and Methods

In this chapter the aim and methods of this thesis will be presented. The subject for the study, and the methods used, were discussed and decided in consultation with Lotta Johansson and in accordance with the wishes from the rest of the staff at Navet.

2.1 Research Questions and Aim

For a visit at Navet to be truly meaningful, it should consist of pre-visit work, the visit and post-visit work. I have, in accordance to Navet's wishes, chosen to research the post-visit work, the boxes with experiments and other material that Navet lends out to the visiting school classes, and what the teachers think of these boxes. Maria Ferlin (2002) touched upon this subject in her C-level thesis *Extramuralt lärande på Navet* (Extramural learning at Navet). Teachers she had met during her research had asked for more specific instructions to the experiments in the boxes. One reason for this might be that a lot of teachers feel insecure when it comes to science and technology. Especially teachers that are specialised in language and social sciences, but that still have to teach science and maths.

The research questions are:

- To what extent are the boxes used during the time they are in the classroom?
- What are the teachers' opinions of the boxes? Is the material relevant, useful and understandable?
- Does the content of the boxes correspond to the goal of the theme?
- Do the teachers change anything in their lessons after a visit to Navet? Do they start using any of the methods used at Navet for presenting science?
- Do the teachers reconnect to the visit and the boxes even after the boxes are returned? Or is the visit disconnected from the rest of the schedule in school?

It would be a very interesting result if the teachers were so much inspired by Navet and their pedagogical methods that they after a visit start using science centre-methods in their teaching, if they did not already do that. In some parts of Sweden, visits to a science centre are mandatory for students at the universities teacher programmes. I have, while working as a support teacher, detected a difference in attitudes and teaching methods between the teachers that got these visits during their university education and those who didn't.

The aim of this study is also to give Navet a good view of how the boxes work; what the teachers think of them, how the material work in the classroom and what can be improved, added or subtracted. The work with the boxes is always ongoing and Navet strives for boxes that are truly meaningful and useful for the teachers and pupils. Therefore Navet wanted an evaluation to help with the development of the boxes.

2.2 Methods

Teachers have a very tough schedule, especially right before the summer holidays, so to get the information needed for this thesis in the short time span available, rather thorough questionnaires were sent out, and four focus groups with teachers were put together for a more complete picture of teachers' attitudes. Two of Navet's pedagogues that have been with Navet from the start were also interviewed. The questionnaires have given quantitative information of what the teachers think about Navet and their method of presenting science and mathematics. The focus group-interviews then gave a more qualitative view of the teachers' opinion on the post visit-work with the boxes.

The fieldwork was intended to both give Navet knowledge about how their boxes work, and give some information on how to change them to the better. The research was meant to lead to developmental work for Navet. There is a difference between development work and research and investigation (Patel & Davidson 2003). Research and investigation are used to produce knowledge, while development work is meant to lead to a change.

The questionnaires were sent out to teachers that had visited Navet from January 2004 to the end of March 2004. I came to Navet on the 1st of April 2004 and thought it necessary to limit the number of teachers to the ones with their visit to Navet fresh in their minds. The names of the teachers were taken from the booking lists at Navet. Usually a school group has more than one teacher with them, but only one name will appear on the lists. The teachers were asked, in the letters sent to them with the questionnaires, to make a copy for their colleagues. In the letters I explained who I am and why I wanted them to take a few minutes to answer my questionnaire. The questionnaires were numbered, for me to know who to remind if the questionnaires didn't come in on time, but I pointed out that they would be anonymous in this thesis.

When meeting with the focus groups, the questions from the questionnaire was used as a frame for the interviews, but the conversation often led a path of its own. The qualitative interview, according to Kvale (1997), is half-structured, it is neither an open conversation nor a strictly structured questionnaire, but something in between. It is concentrated around themes or loosely organized questions, and the purpose is to understand topics from the interviewee's point of view. The written and recorded answers are then the basis for the interpretation. When transcribing the interviews one can take away redundant material and only keep the relevant things for the analysis. What is relevant depends on the aim of the study.

The interviews were conducted with four focus groups from schools in the Borås area, in this thesis called school A, B, C and D. The fifth interview was conducted with two of Navet's pedagogues. The aim of this interview was to find out if the boxes worked as Navet had originally planned, or if the teachers perceived them in another way.

To get a proper background for this thesis, literature about science centres, pedagogy and learning theory has been studied. The literature presented in this thesis is by no means complete. Some books and articles have been difficult to find and some not available at all during the time for this research.

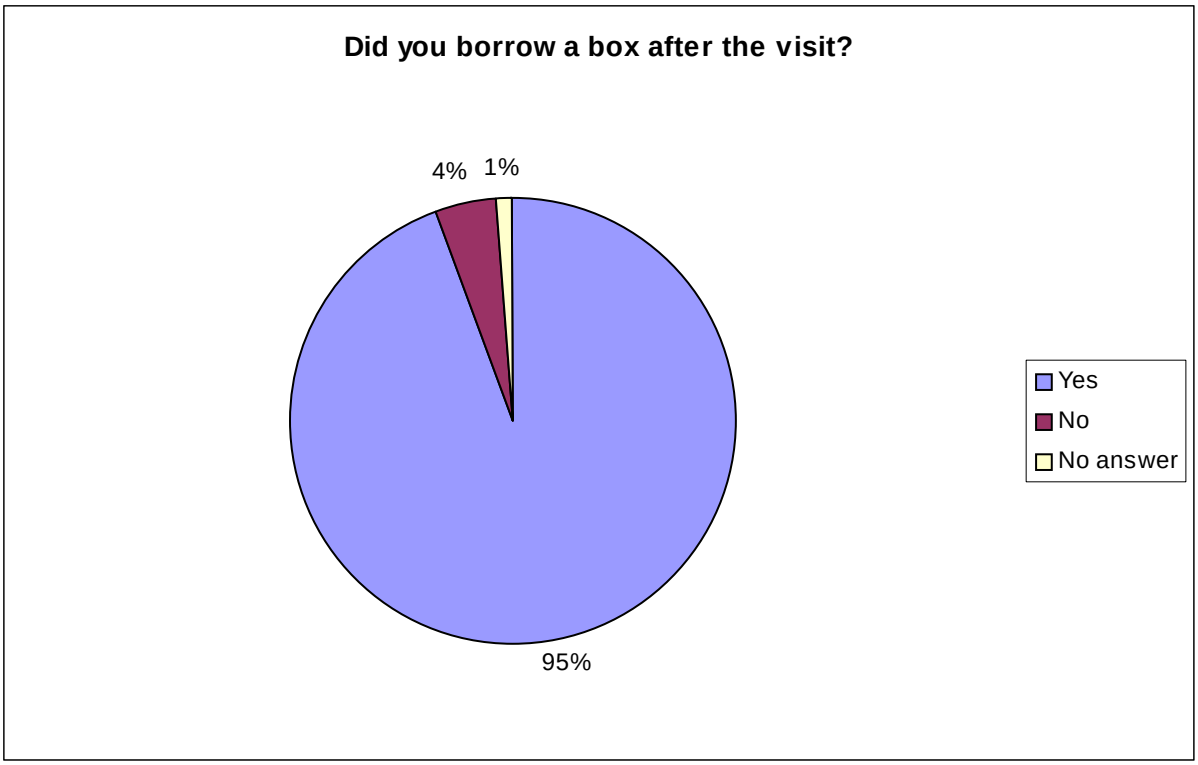
3. Results

In this chapter, I will present the most important and relevant findings from my questionnaires and interviews. The original questionnaires, the answers compiled in an Excel-document, and micro cassettes with the interviews are in the author's possession and can be presented if needed. Both questionnaires and interviews are in Swedish. The questionnaire answers used in this thesis can also be presented in English.

3.1 Questionnaires

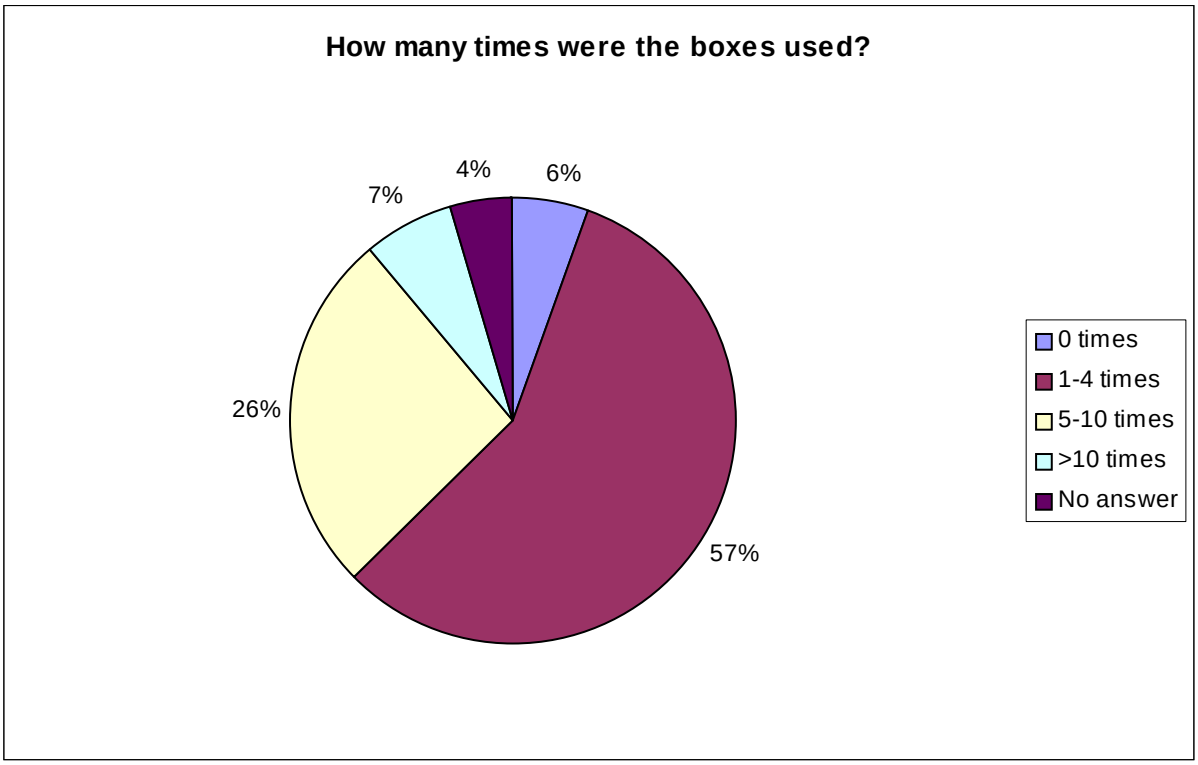
261 questionnaires were sent out and 179 of them were sent back, including 13 extra that had been copied to teachers not in the booking lists. This means that 64 % of the sent questionnaires were answered (excluding the 13 extra).

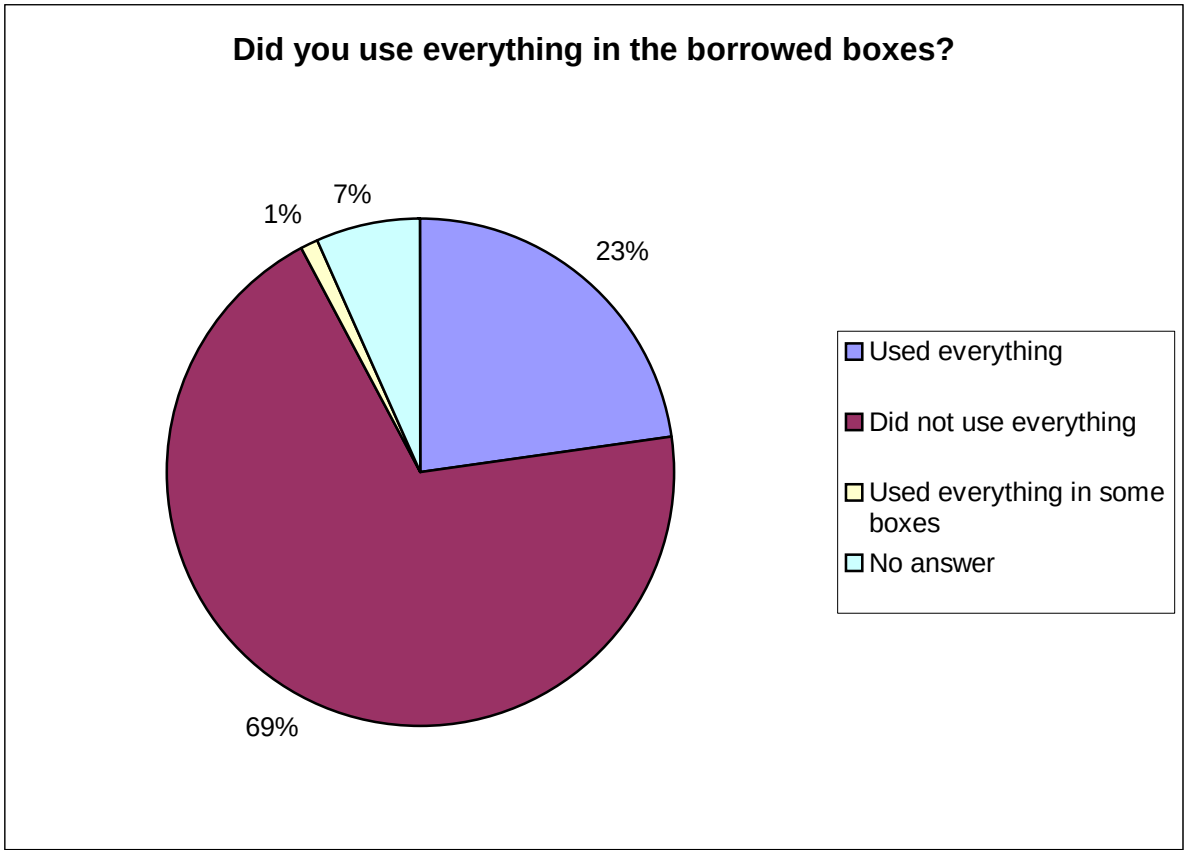
The questionnaire consisted of 22 questions of specific and general character. The questions were chosen to get the information needed for this thesis, as well as information about Navet and science centres in general, to get an idea of how the teachers perceive these institutions. The information not used in this thesis can be used for another report for Navet to use in their work.



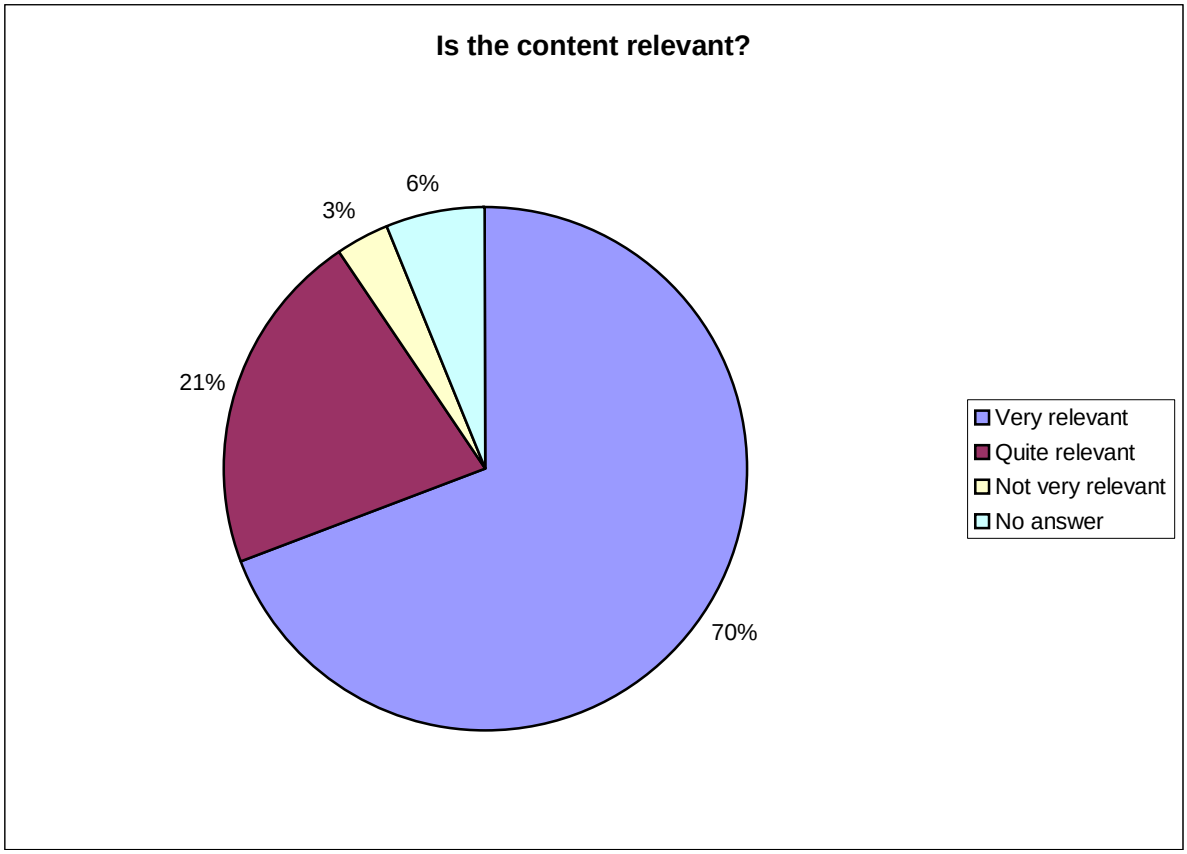
The reasons for borrowing a box were many: they wanted to continue working with the visit, they thought it would be fun with more experiments and practical work in school, they thought the boxes to be inspiring and exciting, they wanted help with more fun teaching in math and science, the children were inspired and wanted to go on working like that, and they saw the boxes as a way of securing the knowledge given at Navet. Most teachers want to do some follow up work, but since many schools lack the material needed, the boxes are an appreciated element in a visit to Navet. The boxes are also seen as time savers: many teachers want to work more with experiments, but they feel they don't have enough time to do both the regular work and also find suitable experiments and the material needed to perform them. One teacher also copied the text material in the box to be able to do the same things with other pupils in the future.

The reasons for not borrowing a box after the visit were: too easy for upper secondary school, had a box at the school already, had already done similar things, the visit was an ending to a theme, it was a visit with someone else's class (substitute teacher).

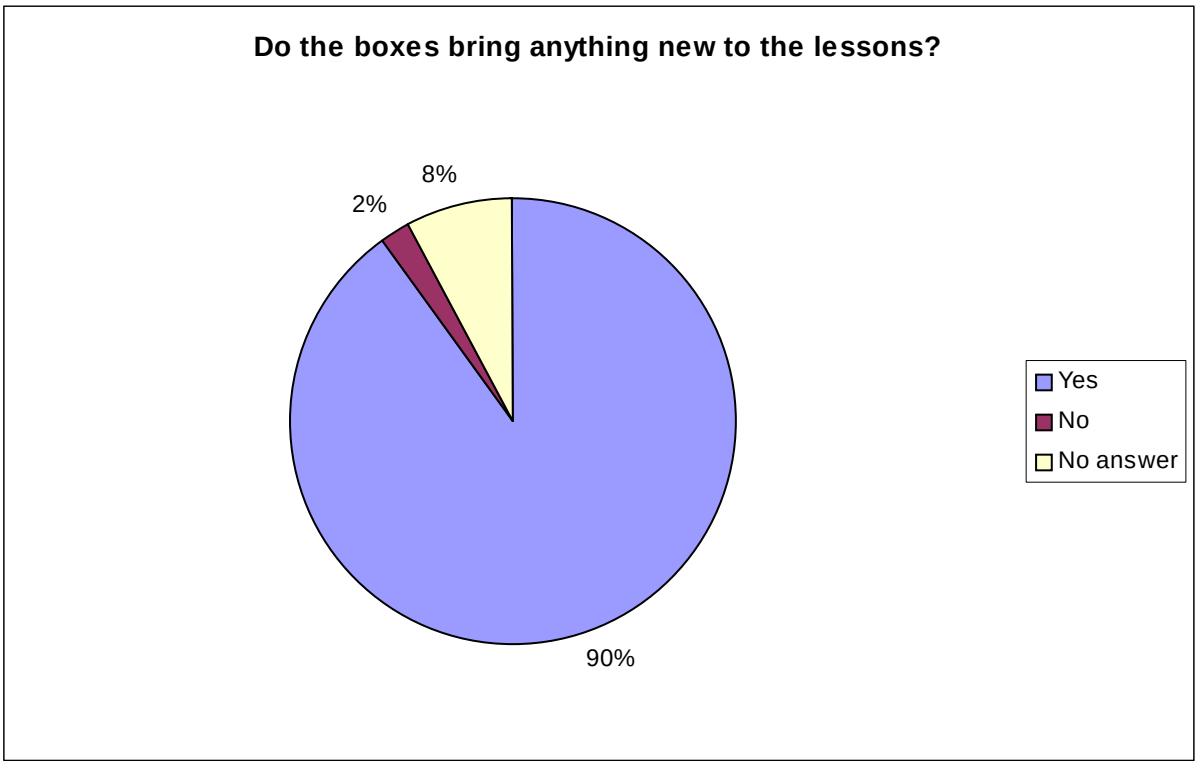




The most common reasons for not using everything in the boxes are lack of time and that not everything suited the level the children was on; some things are too difficult for preschool children for example so instead the teacher chose the things suitable for the pupils and left the rest, and some things are too easy for upper secondary pupils. Another reason for not using everything in the boxes was that they had already done the same or similar experiments in the classroom. Many teachers felt that some things in the boxes were too difficult, both for them and the pupils. For example, the rules to some games in the Math box were too hard to understand and could have needed a more thorough explanation.

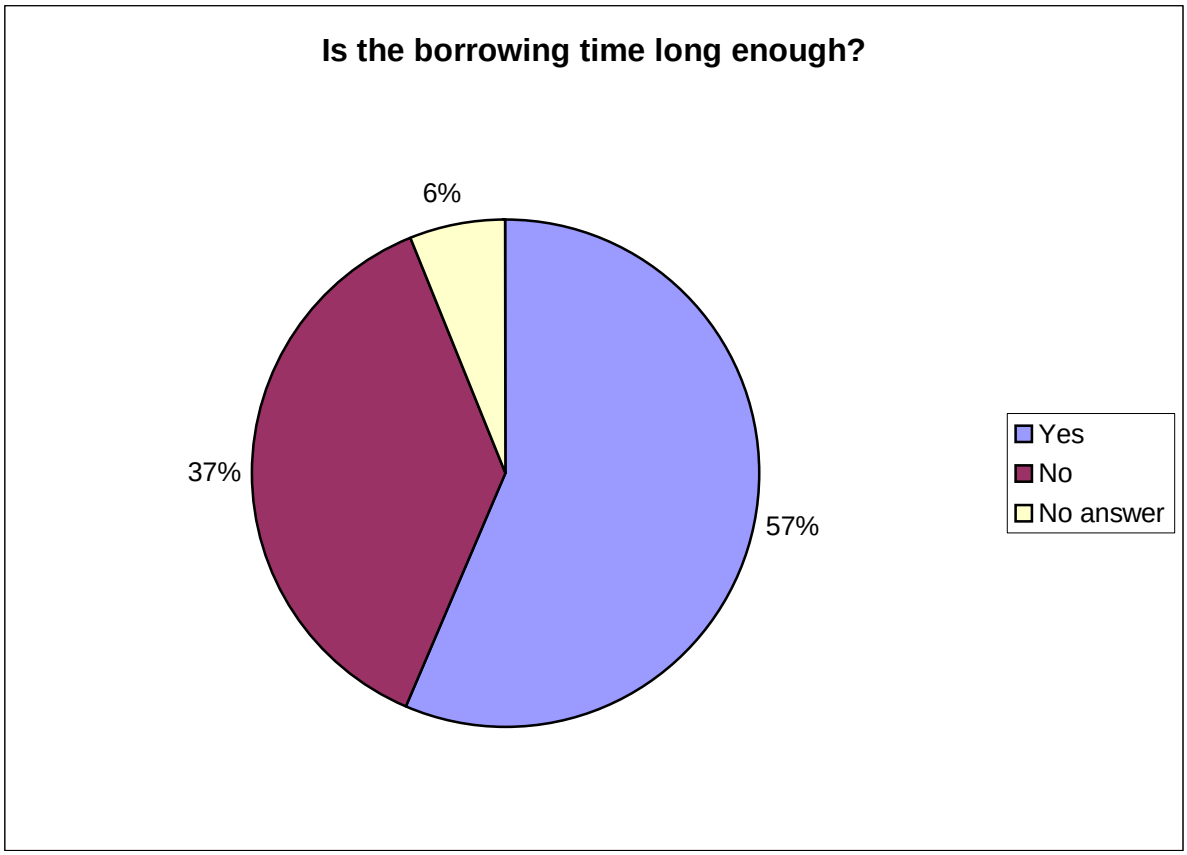


6 teachers answered that the content was not very relevant. Of those 5 had been to the Space theme and 1 to the Water theme.

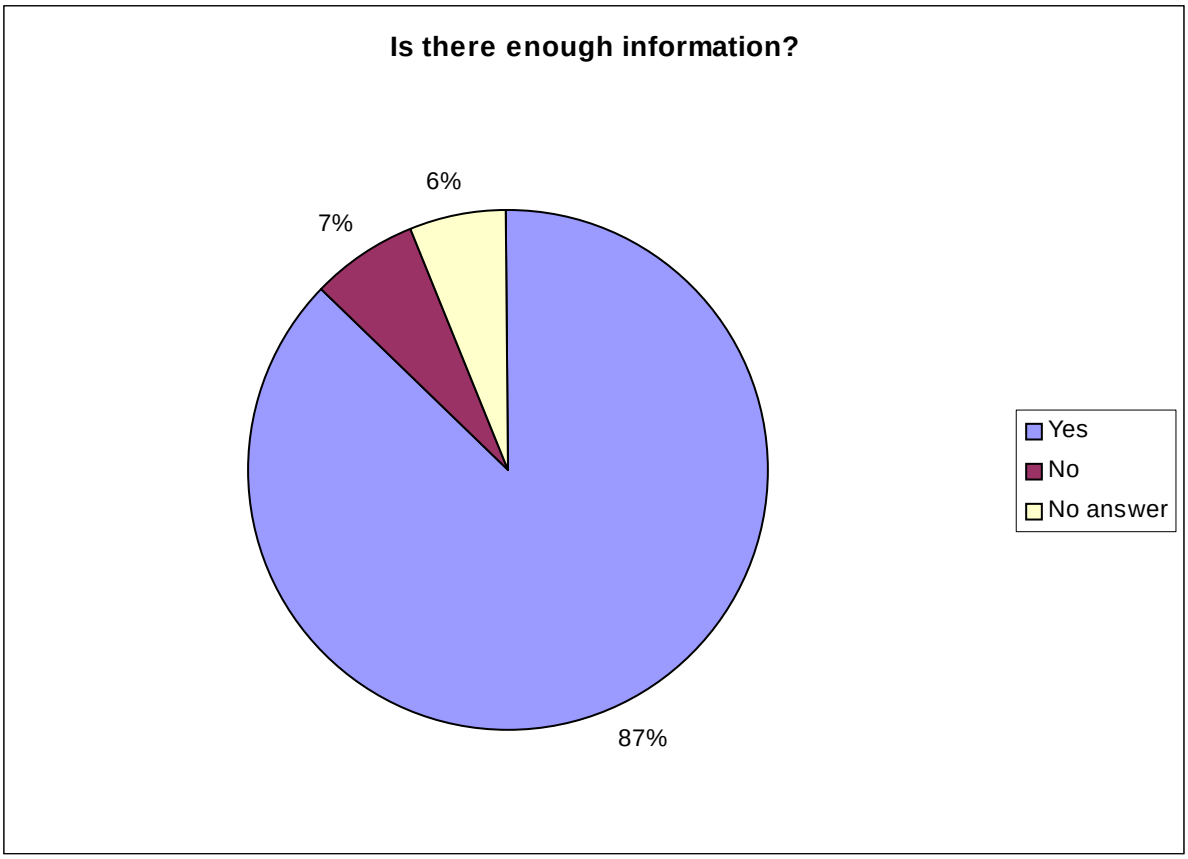


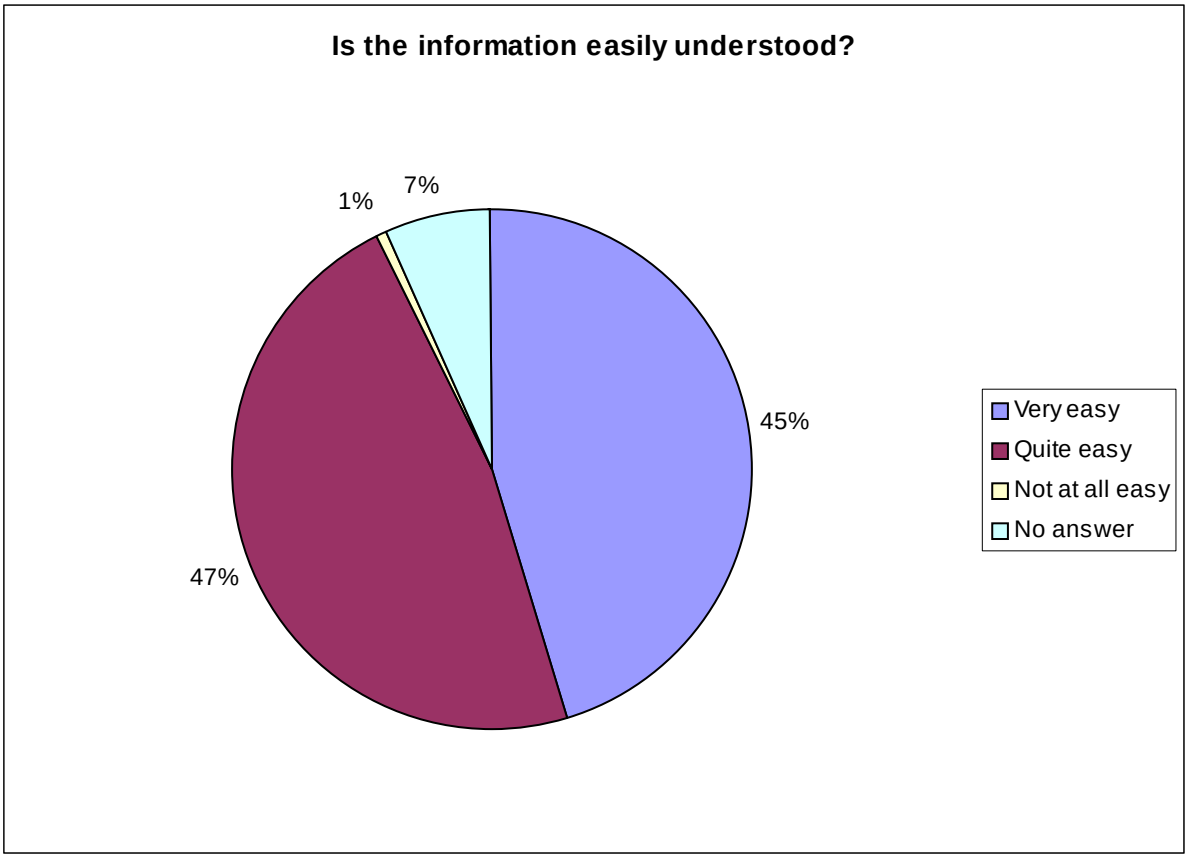
Many positive comments have been given about what the boxes bring to the lessons. Many schools lack the material to experiment, so the boxes give the teachers and the children an opportunity to experiment and do more practical work in school, an opportunity to a more varied education. The experiments might not have been done without the boxes. The boxes are found to be inspiring, fun, educational, appealing to the creativity, and they help to start discussions. Many teachers have pointed out that both children and adults learn better by practical work. The boxes are the practical complement to the theory in school, and they are a big help for teachers not too well into math and science. The personnel at Navet have the schools' syllabus in mind when planning the themes and teachers feel that the boxes connect to different parts of the education, and they are a practical complement to the theoretical part of the teaching.

Two teachers, visitors of the Space theme, did not think that the boxes brought anything to the education because they did not include anything new.

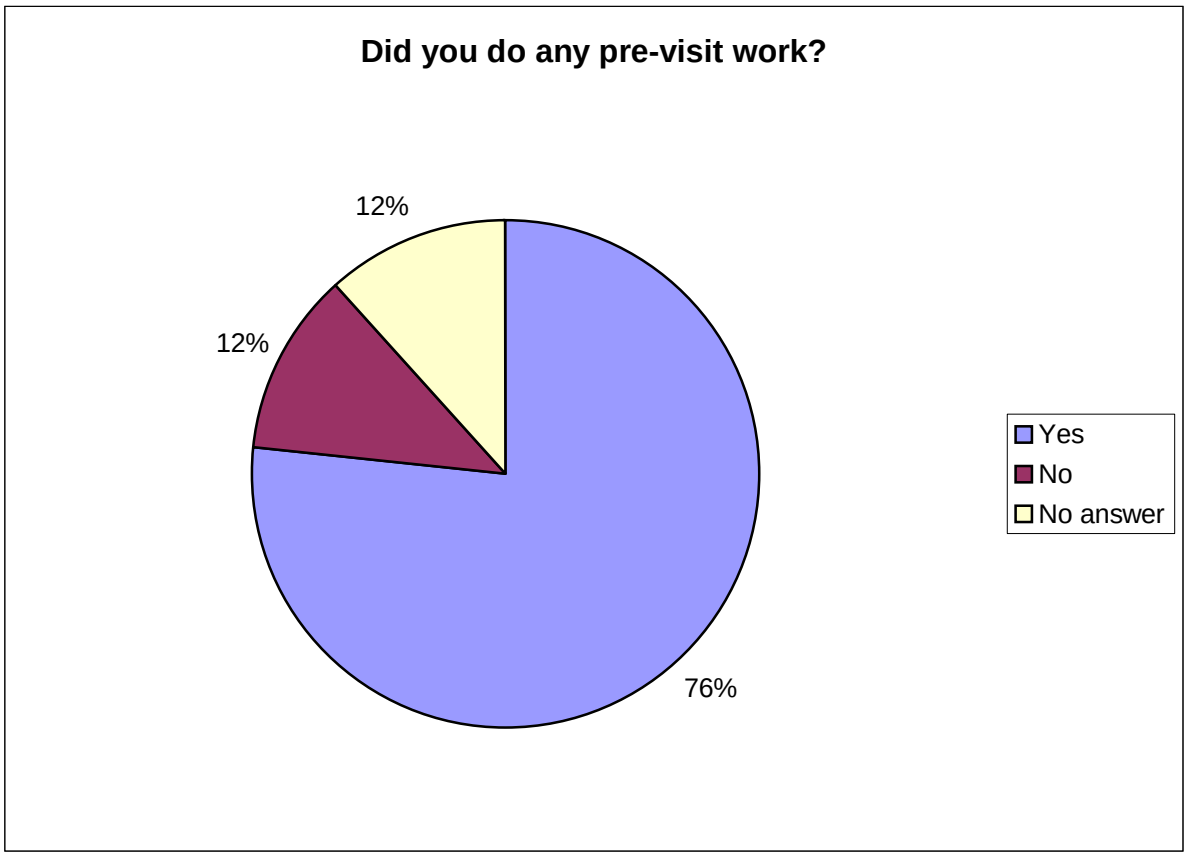


When holidays or similar things interrupt the borrowing time, then it might be a bit too short.



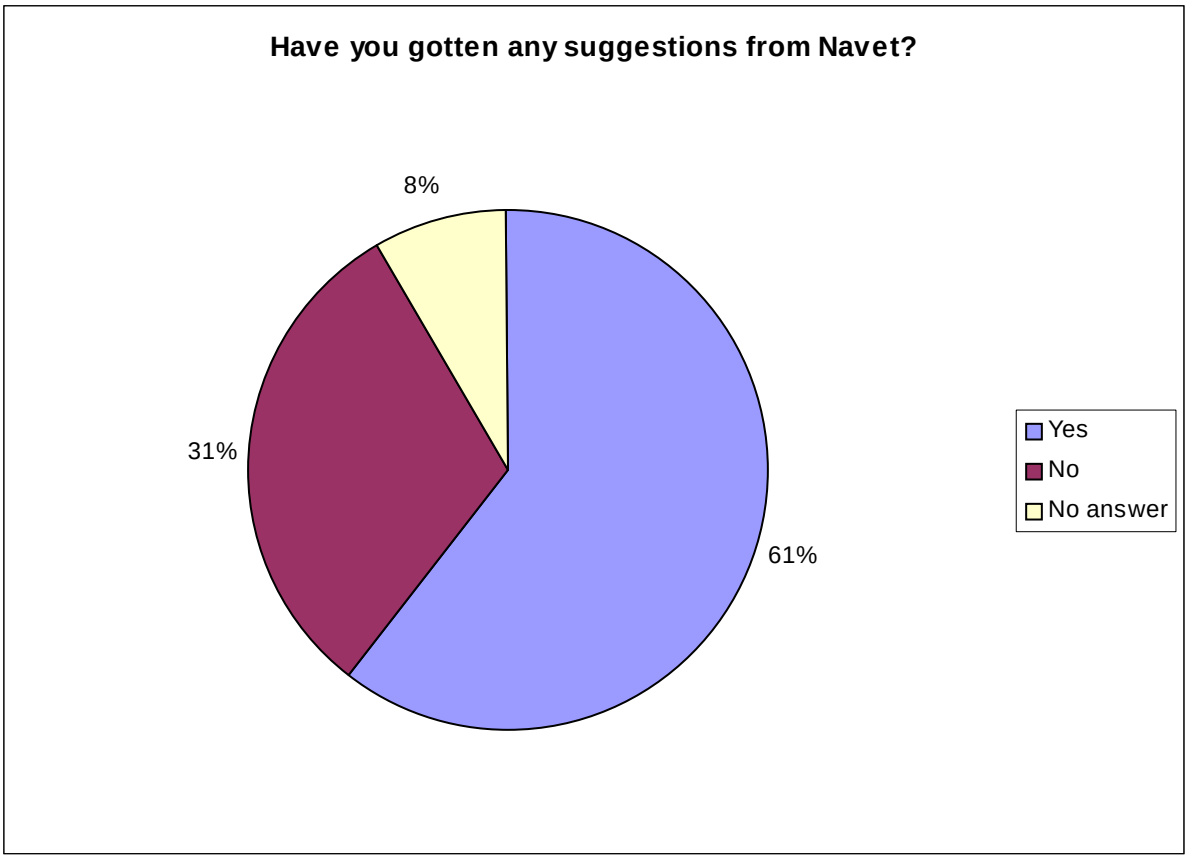


One teacher said that all boxes except the one for the Space theme had easily understood information.



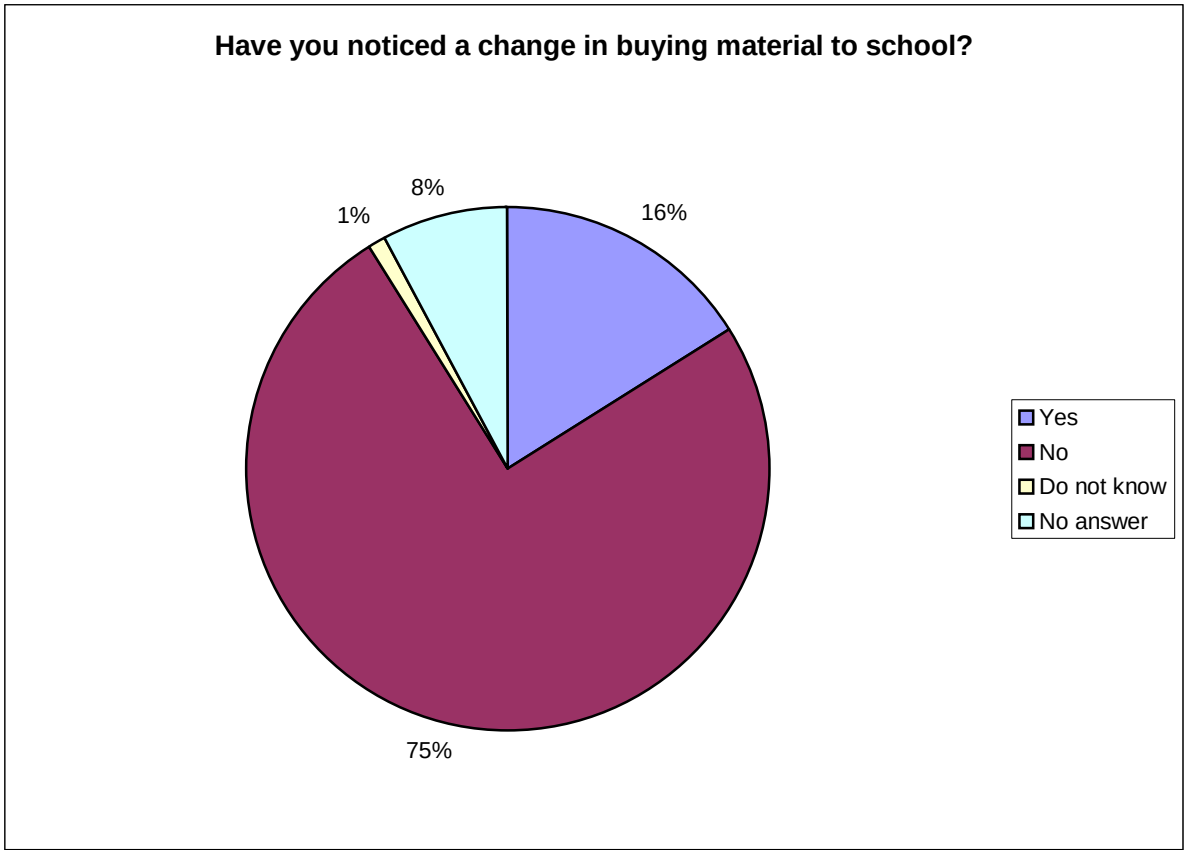
76 % of the teachers who answered the questionnaires had done some pre-visit work with their pupils. Of the remaining 24 % there was an equal share of teachers who had not done any pre-visit work and teachers who gave no answer to that question.

The amount of pre-visit work done varies a lot. Some classes have only made the pre-visit assignment, while others have integrated the visit in a bigger theme in school and have spent several hours a week for a couple of weeks working with the theme before the visit. One reason for some classes not to have done any pre-visit work may be that the internal mail in Borås sometimes is too slow for the assignment to reach the schools in time.

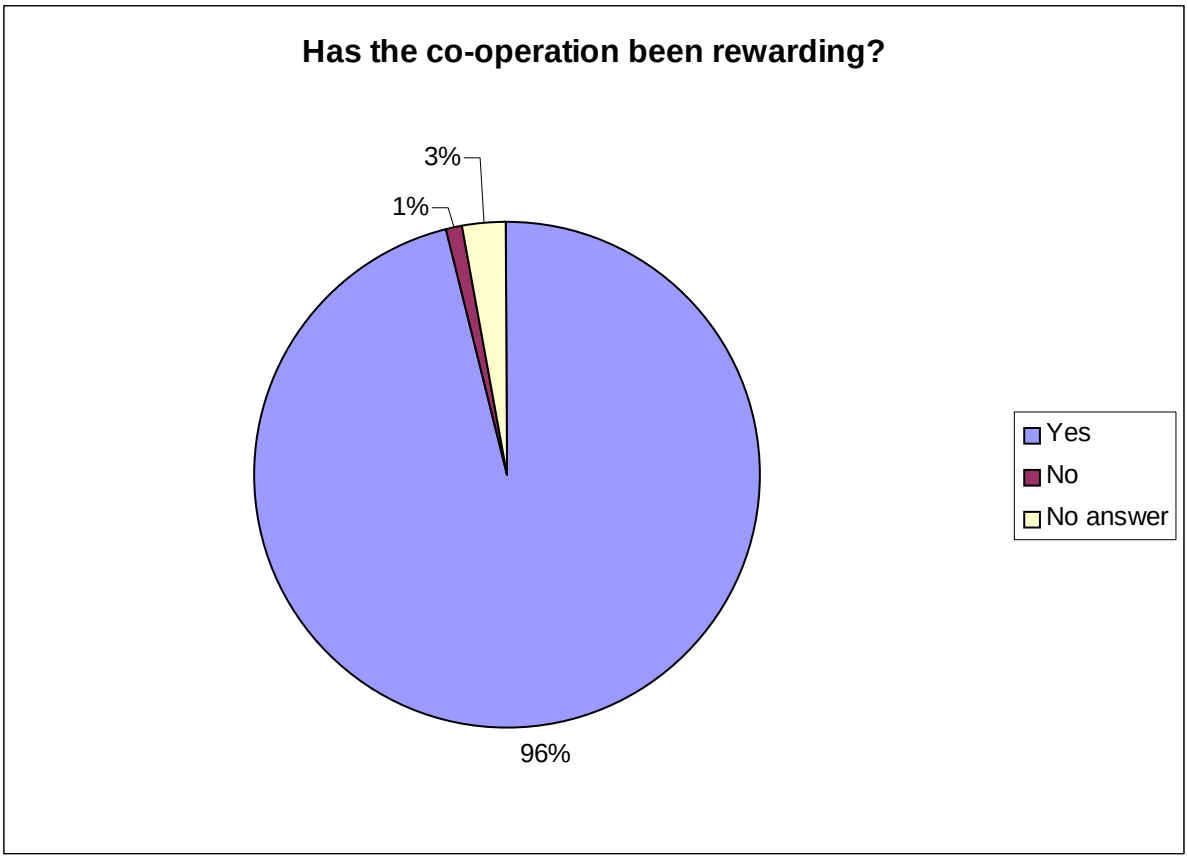


60% say that they have gotten suggestions from Navet. 31 % says no, and the rest did not answer. The comments from the questionnaires reveal that many teachers have become more inspired, have dared to leave the textbook behind sometimes and experiment more, and have included drama in their teaching. One teacher said that Navet made her understand the pedagogical value of dramatization. Navet has also shown that one can vary the education even with small means and every day material.

The teachers that have gotten no suggestions from Navet say that they already work in a more practical way. Some have also mentioned that they have gotten no suggestions, but Navet makes their work easier and it gives them inspiration. A few teachers also point out that they get suggestions and inspiration from everything around them, not only Navet.



16% of the teachers have noticed a change in the buying of material after the co-operation with Navet started. Many teachers want more material to the schools, but it is usually a question of money; either the school has none or the teachers do not have time to plan and buy all the material needed before the 15th of October, after that they are not allowed to buy more material. Some teachers say they do not need more material because they can borrow all they need from Navet. Others are hoping they will get more money soon, to buy what they want and need. Of those who had noticed a change, one teacher's school had decided to buy NTA-boxes, two teachers pointed out that Navet had taught them that the experiment material does not have to be expensive, so they had been able to get new material for school.



96% say that their co-operation with Navet is a rewarding one. 1% says no, and 3% did not answer. The co-operation is rewarding because of several different reasons. Most have to do with the inspirational and educational experience given to children and teachers, and the competent staff.

Of the two teachers that did not believe it to be a profitable co-operation, one said it was because they had only had a study visit there, and that is too little to build an opinion on.

Of the 167 answers received for the question “Is a science centre a good complement to formal school education?”, all but one teacher (who answered ‘don’t know’) believe it to be so. The main reason for science centres to be a good complement is that they have expertise knowledge and resources not found at the schools. Some material is too expensive for schools to buy and some exhibits are so big that it would be impossible to do similar things in a school building.

3.1.1 Comments From Teachers

In the end of the questionnaire, the teachers could write down their own general comments. Here follows a few of them.
“Learning by doing is important!”
“Navet is a goldmine!”
“Navet is a natural part of our teaching.”
“Navet is good for teachers without science education.”
“I don’t have any education in math and science, so it’s good with science centres.”
“A guided visit is necessary for it to give anything.”

Some teachers would have visited Navet more often if they had gotten more than one paid bus trip per semester. Many say they want to come back to Navet, to all the themes, and some want to visit Universeum in Gothenburg too. Some think the dramatized introductions are too childish for the older pupils, while others think Navet has done a good job with adapting the visits for different age groups. Many teachers want both a proper visit and some time for the children to run around on their own, looking at everything, not just the experiments connected to the visited theme. Some believe it is impossible to do the same things in school. There are no such resources. Several teachers commented on the Space box, and did not believe it to be very good. Some believe it is necessary with guides at a science centre, for the visit to be meaningful.

3.2 Interviews

In this chapter the most important facts from the five interviews with teachers and pedagogues are presented. The interview questions were taken from the questionnaire form, and the meaning of the interviews was to get more qualitative information than the questionnaires could give.

3.2.1 School A

The focus group consisted of 6 teachers of varied age and background. Only two of them were primarily science and mathematics teachers. Two of them worked in pre-school and the other four were junior- and intermediate-level teachers.

Teachers from school A have been to Navet with children from preschool to grade 6, and they have visited the themes Light, Mathematics, Space and Water and borrowed the boxes connected to the themes. The boxes are well known by the teachers at school A, since they have visited Navet many times and are planning more future visits.

All six teachers think the boxes are a good idea. The teachers want to have varied lessons with practical assignments for the pupils, but collecting ideas and material take both time and money, something that is not always available. With Navet's boxes, they do not have to do that. The boxes contain everything needed and it is easy to use, whether teaching pre-school children or pupils in higher grades. The boxes are making both teachers and lessons more effective. The material in the boxes is made up of common objects, used in everyday lives, which makes the pupils comfortable around them. The pupils also get an understanding of how science and mathematics fit into their lives.

The teachers agree that Navet is a good resource and help to all of them. Navet is a support for the teachers insecure in math and science, but still on a level also suitable for teachers primarily focused on those subjects.

When it comes to the importance of the boxes, the teachers believe that a visit to Navet is sufficient in itself, but the boxes are a good way of continuing the visit at school and deepen the knowledge gained during a visit. Both teachers and pupils are very motivated after the visit and therefore it is a good idea to keep working with the theme in question. The boxes allow the teachers to do things with their pupils that would not have been done otherwise, owing to lack of money, resources, time etc. The teachers believe the content of the boxes to be rele-

vant and useful and they fit in with the schools curriculum. The boxes, with their fun content, also rouse an interest in those not interested in science already. “It planted a little seed” as one of the teachers said. (This quotation is often used when describing the role of science centres.) All teachers also agree that children learn better when they are doing things with their hands, instead of just reading about it. And this is where science centres play a big role.

All the boxes are good, but in different ways. The Space box has many interesting books for example, but not as many experiments or things to do with the pupils, as the other boxes. It is more information to the teacher. The Mathematics box splits the class into smaller groups, while the Light and Water boxes have more experiments. The Mathematics box could use some more information. Sometimes it is difficult to know which game is which and the rules are not always very clear. One teacher also asked for more practical assignments in addition to the games and riddles already in it. Some schools might already have the games and books with riddles that are in the box, and to avoid monotony, it would be good to include other things, such as outdoors’ assignments; measuring, counting objects and phenomena etc.

All teachers think that Navet works for all ages. The dramatized introductions are different for different grades and the boxes include so many things that it is possible to find something appropriate for all.

Sometimes the two weeks of borrowing the boxes are not enough time for the classes. Some teachers think it is a good idea with only two weeks, since it then encourages them to use the boxes intensively, while others need more time to fit everything into their schedule. If two weeks are enough or not, often depends on what else is happening in school at the same time; special projects, holidays etc. The boxes were used extensively by all teachers, sometimes every day during the two weeks of borrowing. One class wanted to use the Mathematics box every lesson, but had to settle for every math-lesson and just a little more.

All the teachers consider a visit to Navet, with its pre- and post-work, as an integrated part of the school’s education. They also see science centres as a good complement to the formal education in schools. At a science centre there are possibilities to do things that are not possible to perform at schools, often due to lack of money, time and space, or even expertise.

Another thing the teachers agreed on is that Navet has to take better care of the pre-visit work the school-groups bring with them to the visit. It is sometimes forgotten or just barely looked at. Especially the younger pupils are usually very proud of their work and they want the staff to recognise their hard work.

3.2.2 School B

At this school the focus group consisted of three senior level math- and science teachers. They are regular visitors to Navet and have been there with pupils from grade 7 to grade 9, and to all themes available for these grades. This school has the great advantage of being within walking distance of Navet.

All three teachers have visited Navet from the start and are very familiar with the boxes. They have used them extensively, and they always borrow them. In the beginning it was very exciting for both teachers and pupils. Now, after several years, they know the boxes well and sometimes even forget to use them. One teacher pointed out that it could be a good idea to

have a list of the boxes contents on Navet's web site, to make it easier to plan and integrate them with the lessons. Otherwise there is a risk that the class has already made the experiments included in the boxes.

The teachers at school B has the same comment as the ones at school A – it is good that all the material needed is included in the boxes, the experiments might not be done otherwise. School B has quite good resources and probably material to make their own experiments or their own boxes even, but due to lack of time and energy, this is not happening. Instead they use the boxes from Navet.

A visit to Navet could very well stand alone, without the boxes, but they help to further elaborate and develop the subjects. Some boxes might be better as an introduction to a subject, while other would serve best as a conclusion. This is something that emerges after using them for a while.

The boxes are easy to use, but the Mathematics box could use some more information, as some game rules are not very clear. The Mathematics box does not always feel very relevant since the school already has many of the games included and some things feel more important for younger pupils that do not have a very well developed logical-mathematical thinking yet. It should include more things to develop the spatial thinking. The Water box also feel more relevant for younger pupils, but it can be used also at grades 7-9, if a little modified to fit their lessons. They all agree that all the boxes might be more important for teachers in lower grades, where they might not feel secure with math and science, but they still have to teach it. The Space box did not include much to do for older pupils either. It is mostly theoretical at a level too low for the senior levels in school.

The borrowing time of two weeks are seldom enough. 4 weeks would be better, even though a longer time can lead to that the boxes are forgotten. When two classes borrow a box together they get 4 weeks, and then it works better.

Navet has become a part of school B's education, and even without the boxes they do post-visit work of some kind for maybe two weeks.

Thoughts of more varied and fun way of teaching has always existed, and Navet is a good source of inspiration and help. Maybe it is so that teachers that are not interested in this way of teaching do not even visit Navet or other science centres at all. Science centres are a good complement to school education. Some things can be done at school, but the dramatised introductions and experiments of bigger scale are not possible there. A teacher at the senior levels usually works alone with the class. If they had worked in pairs or groups, it might have been easier to work with themes, experiments, drama etc.

The pre-visit assignments are a good way of getting the pupils interested in the visit and thinking of the specific theme, but they are sometimes a bit too childish for the senior level pupils.

3.2.3 School C

At this school seven teachers from pre-school to intermediate level participated in the focus group interview. One was educated in math and science, two in social science and Swedish and the rest were educated when there were no concentration on specific subjects. Teachers at school C have visited the Human Body, Energy, Math, Space and Water.

They do not believe it to be very important at the lower levels what subjects you have in your education; you still have to teach them all, but for those who feel they are not enough educated in math and science Navet is a big help. The boxes are appreciated by all teachers, but maybe most of those who lack in math and science. The boxes give ideas and suggestions on how to vary the lessons. It is good that the boxes contain everything needed for the experiments etc. The teachers always borrow the boxes after a visit, because they are so inspiring.

The information and instructions in the boxes are clear and easily understood. It is good that it also says what is supposed to happen during the experiment, so the teachers know if it goes right or wrong.

The teachers believe a visit to Navet is enough in itself, but the boxes serve to deepen the knowledge. It is fun to be able to continue back in school after the visit. When possible, the teachers visit Navet in connection to themes they are working with in school. After a visit, both teachers and children are very inspired and it is fun to work with the boxes, which are considered to be a part of the schools education. Sometimes it is hard to plan how much the boxes can be used. The content is not always known in advance, so at times the experiments have already been made or they don't fit into the schedule. Sometimes Navet is fully booked and they have to make the visit at the end of a theme in school. In those cases working with the boxes does not seem as important.

The school has quite a lot of material and resources, but it takes too much time and effort to gather the things needed for experiments etc. And things are hardly ever replaced when lost or broken. Before their co-operation with Navet they rented boxes from 'AV-centralen', that rents out and sells teaching aids such as books, films etc, but that is hardly ever done anymore.

The contents of the boxes feel relevant and connect back to the visit. The teachers would like some information on the boxes before the visit to make it easier to plan the post-visit work. The Mathematics box includes many games that the school already has in their possession. The Space box seemed a bit difficult for the youngest children. The Water box contains experiments often included in teacher guides, and has thus often been made already. The teachers do not think Navet should make boxes specific for the different grades in school. Quite often children in the same grade are on different intellectual levels, so it is better for the teacher to choose from the material and pick what is suitable for the pupils.

Navet helps the teachers to develop their teaching, but this kind of thinking is not new to the teachers. Some of the teacher teams at the school, work quite a lot with drama already. They usually start every new theme with a dramatised introduction to awaken interest and fascination in the children. This might be more common in the lower levels of school. Several teachers have also been to courses and seminars at Navet and are very appreciative of these opportunities to further education.

The teachers believe that Navet's way of working is good. The pupils like doing the pre-visit assignments and they create anticipation before the visit. But the staff at Navet should take better care of the work they leave in. The children want to show off what they have done, maybe even see it in place at Navet when they arrive.

3.2.4 School D

The three teachers at this school have been to Navet with pupils from grade 1 to grade 3, the junior levels at school. They are all regular visitors to Navet and have been to Chemistry, Digestiva, Energy, Light, Math, Space and Water.

They have borrowed boxes after all themes except for Digestiva and Light, that did not have boxes at the time of the visit. They usually borrow the boxes after a visit, but not if the visit is the end of a theme in school, because then it does not connect to the regular schoolwork planned.

It feels great to be able to borrow the boxes. Without them these experiments would probably not be done. It is very appreciated that the boxes include all the material needed. The Space box is not as good as the others. There is a lack of tangible objects and experiments in the Space box, and it is therefore not as much fun for the children. It mostly contained books that are easy to find anyway. The Mathematics box contained so many things that they did not have time to do it all. But that is better than the other way around. It is good that the Mathematics box show that math is so much more than numbers. Some of the games are already available at the school, so the box was more of something extra on the side. The Chemistry box on the other hand became a big part of the lessons. Those experiments would certainly not have been done without the box. The Water box was very good and exactly what they wanted and had expected. The Mathematics box gave very active children, and they usually played in pairs, while the experiments in the Chemistry box had to be done in bigger groups or even the whole class together.

The boxes are great and should not ever be taken away. They add a lot to the teaching and provide the teachers with ideas. If the visit to Navet is an introduction to a theme, the boxes are worked with extensively. They make it easier to plan the lessons, since they contain all the material needed. The boxes are a great complement to their ordinary lessons. The information is good, detailed and easily understood. The school once had their own boxes, but much of the material is now missing and no one has the time to fill them again. They also used to rent boxes from 'AV-centralen', but those cost and there is not always money for it.

The borrowing-time is long enough, if holidays or other special things do not interrupt it. Not all teachers knew that they could prolong the borrowing-time if needed. But usually they work with the boxes intensively just because they know that the time is limited. The boxes are not always used every day. It depends on what they have already done and what suits the children. The Chemistry box was used every day; one experiment a day until all was made.

Navet is an integrated part of their teaching. They go there at least once a year, but would like to go more often, at the beginning of every new theme in school. Navet is also a good place for inspiration and new ideas. They think science centres are a good complement to school education, and they are very happy with the co-operation with Navet that they have had since

Navet started. They sometimes use drama in their teaching, but it is more fun to go to Navet for it.

The teachers are not completely happy with the pre-visit work. The assignments are a good introduction to the visit, but the personnel at Navet do not pay enough attention to it when the children come to Navet. Maybe the work of the children should be sent to Navet and put up in advance, so the children can see it put in place. Or the children should get a chance to present, explain and discuss their work at their arrival to Navet.

3.2.5 Pedagogues

This interview was conducted with two pedagogues that have been at Navet since the start and have been a big part of developing the boxes.

The themes at Navet are directed towards different school levels. Some themes should maybe be looked over so that they really fit the intended target groups. They look at the schools' syllabus when working out new themes, but they are not bound by it. But it is good for the teachers to know that the material from Navet cover big parts of the syllabus.

The first real box was developed in the autumn of 1999, and it was the Water box. Before that the assignments were very small scale and they had bags containing only one experiment. The boxes were first made to be a help for teachers not too keen on, or too knowledgeable, in math and science. But after a while everyone wanted to borrow them and so they became a part of a normal visit to Navet.

On a school's first visit to Navet, the possibility to borrow a box can come as a surprise, but often it is expected. Sometimes it happens that the boxes are borrowed even without a visit. The boxes are borrowed after almost every visit. When teachers do not want to take them back to school it is usually due to lack of time, for example at the end of the spring term, just before the summer holidays. The boxes function quite well as they are, but the staff at Navet would like to develop them further. They want the boxes to be better thought-out and have more open-ended experiments. They want the boxes to be a start of something new, and not just be finished when the experiments are done. Maybe they could be organised so that the classes continue a developing work on their own afterwards. But it is a tough balance – the boxes should be challenging, but not too difficult.

The Water box needs to be changed now when they are working out new themes and dramatized introductions. The Energy box needs updating and the Space box needs to become more practical and tangible. The boxes are under constant development, but lack of time is a problem. Sometimes teachers are invited to look through and test the material before they start using the boxes. The Math box is a direct continuation of the work in Bagdad (the math-part of Navet), but the other boxes are more of a broadening of the subjects.

For teachers that are not working much with experiments and more hands-on education, there are too many steps to go through to get there – searching for material, reading, picking out experiments, finding material etc – but with the boxes all those steps are already taken, and it is easy to get going. The pedagogues at Navet are thinking about making boxes with different degrees of difficulty. Not for specific grades at school, but for the different developmental levels the pupils are at.

The pre- and post-visit work is important because Navet wants to be able to influence the schools for a longer period than the 1½-hour visit. Navet do not want the visit to be just a fun thing, they want it to be part of the regular education, and they want teachers to use Navet for their teaching. Navet do not just want to be a place where children run around and play, they want to be a part of a bigger whole. The pre-visit work is supposed to function as an introduction to the theme, and to make the pupils think about the subject before they come to Navet. The use of pre-visit assignments started some time ago, when booked groups forgot the time or day of the visit, and Navet felt a need to remind them and confirm the booking. So they started sending out letters with a small assignment. The assignments work well, but the staff has to take better care of the work the pupils leave to them. It must feel worthwhile to the children. Sometimes it is hard to find a good place to hang the pre-visit work the children hand in. It usually requires the aid of the designer at Navet as well, and due to lack of time and resources, not everything that needs to be done can be done in the desired time.

It is easier to influence teachers that already have this way of thinking; that are already in to informal learning, science centre education, hands-on etc. One way of reaching them is to do it already at the university.

Navet is supposed to be fun, to awaken a fascination for math, science and technology and to offer what the schools cannot manage on their own. Navet also wants to convey a message, which consists of different methods for teaching math and science in school.

Navet does not want the schools to buy the boxes. Then it is a bigger risk that the boxes are just left standing somewhere, or that there is no one to fill them up with new material when needed.

4. Conclusions and Discussion

The quotation from Comenius (1592-1670) in the beginning of chapter 1.3. explains, according to me, why science centres are important and should be a part of both children's and adults' education. When the schools get less and less resources and the amount of help-teachers decreases some children are being forgotten. A lot of children have trouble with sitting still and concentrate through a whole "chalk-and-talk" lesson. These pupils have a need for freer lessons where they can use their imagination and creativity. By using "science centre"-methods you can integrate these pupils better.

Statens Kulturråd - The Swedish National Council for Cultural Affairs (1999) points out that it is very important that museums and science centres become considered as a resource by the teacher programmes at the universities. In this way it is easier to get schools to visit science centres regularly. Several of the interviewed teachers consider a visit to Navet, with its pre- and post-work, as an integrated part of the school's education. They also see science centres as a good complement to the formal education in schools. At a science centre there are possibilities to do things that are not possible to perform at schools, often due to lack of money, time and space, or even expertise.

It is sometimes difficult to draw a strict line between formal and informal education. Formal education institutions have a clear educational goal. This would mean that science centres, with for example school programs, are not strictly informal education institutions. I would say that even if school programs do not exist, these institutions are only on the verge of being informal learning institutions. Every museum and science centre want to teach their visitors something, and educational goals are part of their business. But since they do not have specific curricula, they are still institutions of informal education. With this difficulty of drawing a strict line, Salmi's link between formal and informal learning, the out-of-school education is a good definition for a place like Navet.

We are not really in the information business; we are in the motivation business. (Per-Edvin Persson, director of Heureka in Vantaa, as quoted in Bagge 2003, p 5) For learning to occur, the learner has to be in a positive state of mind. This can quite easily be developed in a science centre (Bagge 2003). I do agree with Sara Bagge (2003) and many other researchers, that a science centre can never replace the formal school system, but it can be a very good complement, not only by giving an opportunity to do things that are not possible in a school building, but also by awakening an interest and a "wow-sensation" about science, that might later lead to more formal knowledge.

As Benzce & Lemelin and Falk & Dierking point out, one needs to understand the place of science in one's everyday life to understand it properly. Unfortunately not all teachers have, according to me, understood this yet. What is taught in school needs to be relevant for the pupils' lives. Schools should not only teach words and numbers, it should also prepare us for life. And this is where science centres have a hole to fill, when they try to make mathematics and science, and even the humanities, available to and relevant for people, something the schools have not always been very successful in.

As stated earlier Falk & Dierking believe it to be important for children to get familiarized with the environment before learning can occur. At Navet, the children go directly to the dramatized introduction and do the free experimentation afterwards. During the introduction they get information and concepts important for learning while experimenting. This is usually not a problem since most children have been to Navet several times, with school or with family during weekends and holidays when Navet is open to the public.

The questionnaire and interview answers show a quite clear picture of what the teachers think of Navet. Most comments and answers given about Navet are very positive. Navet is a well functioning science centre with a special way of working with school children and the public. Schools in the area have an agreement with Navet and use Navet because they believe it to be a good complement to school education and an enormous help with math and science education. Therefore the very positive responses are not surprising.

95 % of the teachers borrowed a box after the visit, and only 6 % did not use the box at all during the borrowing time. Only 3 % did not find the contents of the boxes to be relevant. Of the 6 teachers that answered that, 5 had been to the Space theme. This shows that the teachers do consider the boxes, except the Space box, to be educative, and useful in their teaching, and they usually do not have any problems with integrating the boxes in their normal lessons. Both the questionnaires and the interviews show that teachers that come to Navet regularly use the boxes extensively and consider them to be a part of their teaching. Several teachers also pointed out that Navet develop their themes with the syllabus in mind and that infuses confidence in Navet and the material.

87 % thought that the boxes held enough information, but the interviews show that the Mathematics box needs more information. It is sometimes difficult to understand the rules, especially for the children. The Mathematics box does not always feel relevant either, according to teachers at the senior levels. Usually the schools already have many of the games included and some things feel more important for younger pupils that do not have a very well developed logical-mathematical thinking yet. As pointed out earlier, the boxes were originally planned as help for teachers, and this is a case where the teachers do not have a need for Navet's Mathematics box anymore. Some of the games at this school are actually from Navet's museum-shop.

The Space box got mostly negative responses. This is the newest box and it needs a lot of working with before it is working as well as the other boxes. The pedagogues are of the same opinion as the teachers regarding this. Another reason for the negative response is that the Space box does not contain experiments and practical assignments in the same extent as the other boxes. Teachers expect the boxes to be filled with experiments and all the material needed, not literature that may help them to develop the lessons on their own.

61 % of the teachers say that they have gotten suggestions from Navet to change their lessons. Others say that they already worked like that and have not gotten anything new from Navet in particular, but take inspiration from everything around them, including Navet.

Several teachers that participated in the focus group interviews asked for more detailed information about Navet's loan services. They wanted, for example, a list of the boxes and their contents, because sometimes the experiments included had already been done in school. It can be perceived as a negative thing for the teachers if they borrow a box, bring it back to school

and then do not use it. It might be an unnecessary effort. But it can also be seen from a positive point of view – the teachers that have already done the experiments in school are already working in a desired way of teaching. The boxes were planned from the beginning, as help for teachers, so if they have already done the experiments included that would mean that they do not need the help anymore. The two teachers that in the questionnaires answered that the boxes did not bring anything extra to their teaching because they already worked like that should be very content with the good job they are doing.

Almost all interviewed teachers considered lack of time and money to be the main reason for why experiments would not be done in school in the same extent as with Navet's boxes. Teachers usually have a tight schedule and finding experiments, studying to get the knowledge needed etc, takes time. But once this is done, the teachers will have the information and knowledge needed for experiments with future pupils as well. It is not something that has to be done every time. Money might be the bigger problem. Teachers get a certain amount of money to buy material. But all the material has to be bought before the 15th of October each year. It then becomes very difficult to fill up with the material needed. And, of course, since they can borrow boxes from Navet, even without a visit, it is not necessary to spend the extra time and effort.

Maria Ferlin (2002) wrote in her essay that the teachers wanted very thorough instructions for the experiments in the boxes, because otherwise they would be afraid of teaching mathematics and science. The interviewed teachers for this thesis all believed the boxes to be a big help in their teaching. Some of them are not too well up in math and science, but it is a part of their work and they have to do it. No one said they were afraid of teaching theses subjects, but they are thankful for such help as a visit to Navet and the boxes can give them.

Both questionnaire and interview answers show that teachers use Navet as a part of their teaching. They believe the content of the boxes to be relevant and useful and they fit in with the schools curriculum and the boxes are a good way of continuing the visit at school and deepen the knowledge gained during a visit. Even those who do not use the boxes every day, or even more than once during the borrowing time, connect to the visit during the lessons after a visit, and even without a box there is post-visit work done in some way. Most teachers that visit Navet are familiar with, and agree with, their way of working. They understand the importance of pre- and post-visit work and whether they are aware of it or not, many have a checklist similar to Bitgood's in their minds. The interviewed teachers all agree that Navet has to pay more attention to the pre-visit work the children bring. Otherwise it can become hard to motivate the children for the next visit.

Visiting a science centre once might not result in a lot of new knowledge, but instead a new willingness to learn. One way of making that knowledge long lasting for school children, is to have an active cooperation with the schools. The science centre then has to make sure that: 1) the visit is not disconnected from the school's curriculum, 2) the pre- and post visit work is relevant, both for the visit and the schoolwork, and 3) the subject is not disconnected from everyday life. When it comes to the post visit work, like the boxes at Navet, there are a few important things to remember: 1) the post visit work needs thorough and easily understood information, 2) the post visit work should contain information, experiments etc that is not available at the school, and 3) the post visit work should be of a varied level of difficulty, because pupils in the same class can be at very different levels of knowledge and understanding.

A science centre can never replace the formal education in schools as Ott, among others, point out, but it can be a good complement to it. Many of the teachers that visit Navet with their classes have co-operated with Navet for a while, some from the very beginning, and they agree with that. They see Navet as a very useful complement and use it as an integrated part of their teaching. Usually not everything in the boxes is used. One reason for this is that not everything is suitable for those specific pupils. As many researchers, psychologists and philosophers, for example Comenius, Ausubel, and Vygotsky, have concluded – the pupils should be taught at the level they are on. Navet also believe that different people learn in different ways, and Gardner and Steinberg have both articulated theories that are useful when developing the themes and the material connected to them. This gives the teachers another possibility of finding something interesting and helpful for every pupil in the classroom. And for most people learning by doing is fundamental for long lasting knowledge.

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Appendices

A.1. Example of Pre-visit Assignment (Aviation, translated from Swedish by Renée Göthberg).
A.2. Example of Pre-visit Assignment (Math, translated from Swedish by Renée Göthberg).

B. List of Contents of the Boxes.

C. Questionnaire (original Swedish and English translation)

A.1.

In the 15th century lived a Chinese, Wan Hu, that all his life had had a dream about being able to fly. He made many tries and at last he got an idea. He would use kites. Wan Hu tried with many different types of kites, but discovered soon that the dream of flying was quite hard to realise. The two kites were not enough… What should he do?

Wan Hu asked his servant to get rockets, as many as he could get. It got to 47 rockets that Wan Hu put on his body. He also fastened himself to two kites that hovered high above his head. Strenuously he climbed a mountain. His loyal servant that had accompanied him, now got to light the rockets. It was a violent explosion!!!
Wan Hu flew away… and was never seen again.

WELCOME TO NAVET'S AVIATION THEME

It isn't just the Chinese that have had dreams about flying. Many people share this dream. Many stories show that man in all times has dreamt of flying. We have looked at the birds and dreamt of how to get to higher altitudes…

The fantastic thing is that today we all can fly!
What would life be without dreams?

Here is your first assignment to awaken your thoughts/dreams about flying.

Before you come here for a visit we would like you to make windtwirlies that you can take with you and drop from our balcony at 5 meters height. The windtwirlies should fall as slowly as possible and on the back of this paper you can see how to make them. You can gladly experiment with the size of the windtwirlies.

Have a good time! And don't forget that dreams can come true…

We'll see you _____ at _____ o'clock.

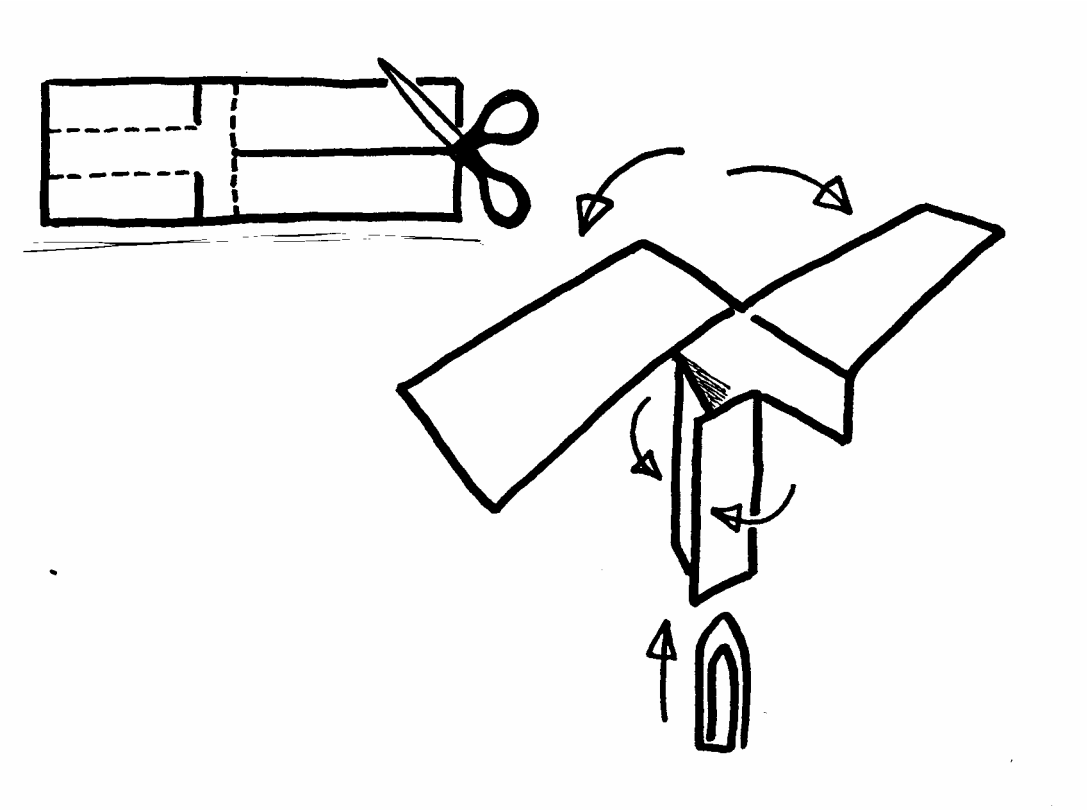
Greetings from NAVET!

PS Bring a list of pupils in your class to put on NAVET's notice board. DS

Windtwirlie

Material: Ordinary writing paper, scissors, paper clip (if necessary) for a weight

Instructions: Cut of a strip of the writing paper, cut and fold according to the figure below.



WELCOME TO BAGDAD,

A.2. NAVET'S MATH-AREA!

Mathematics is an important part of our lives. We all use math every day. Many believe math to be just a math book and a lot of numbers. To count with numbers is a part of mathematics and we have counted, one way or another, for many thousands of years. There are visible traces after human counting, for example a woolf's bone with engraved notches that probably were used as a counting tool. The woolf's bone was a tool that was used about 30 000 years ago.

But mathematics is much more than just counting and we hope that you will experience that when you come to visit. At NAVET, we have built our Bagdad where you can experience, test, try, play and think along with your friends.

But I am not completely satisfied, there is something missing! I would like to have a big colourful painting that will brighten up Bagdad. Colour the square at the back of this paper and bring it to Bagdad. Put together, the parts will become a great painting created with mathematics!

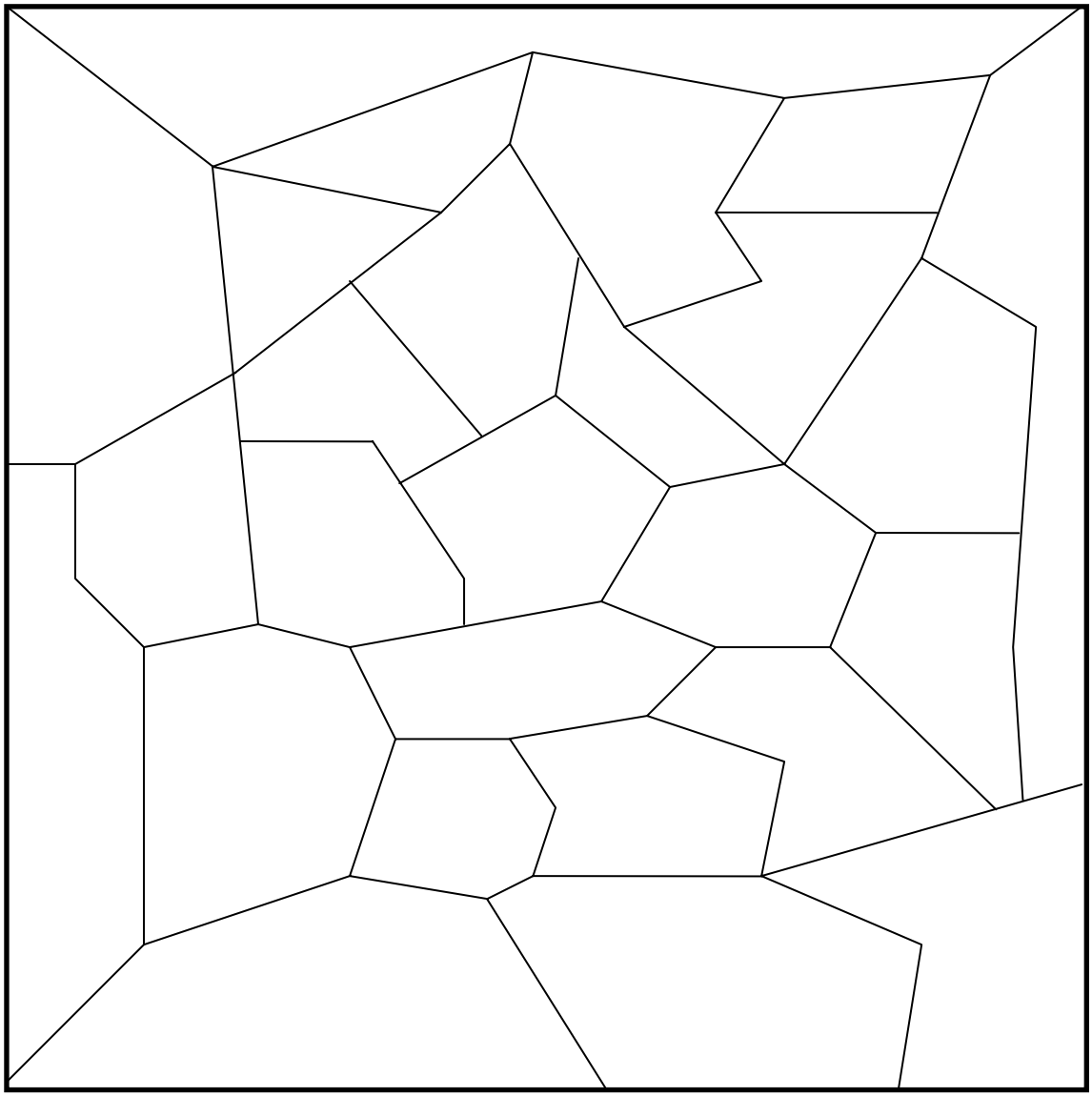
Have fun until we see each other!
Many greetings from Al–Kwarismi

You are welcome here on _____at_____o'clock

During the visit, there is time in Bagdad, the mathematics exhibition. You may experience the rest of the house some other time.

PS: The square on the back of this paper contains a so called four colour puzzle! Copy the puzzle for the pupils, and let them try several times if they need to. Don't forget to cut out the squares and bring them with you on your visit.

MATHEMATICS = BEAUTIFUL SCIENCE



Bring out your colour pencils or crayons. Use only four colours and paint every area in the figure in one colour. Areas that are next to each other should have different colours. If it doesn't work the first time, try again!

When you have finished painting, cut out the square. When you come to Bagdad we will put all the squares together to a big painting.

Good luck!

B. LIST OF CONTENTS OF THE BOXES

Chemistry box

Teacher's manual

"Trolleri och magi, allt är kemi" ("Tricks and magic, all is chemistry", book)

Experiments:

- Make your own volcano.
- The egg without a shell.
- The tea that sticks to the cup.
- The ghost in the pot.
- Colour chromatography.
- The city's dirty air.
- The light in the jar.
- Make your own glistening Gilbert.

Berta the dragon (hand puppet)

Energy box

Teacher's manual

OH-pictures for experiments

Experiment guide

Compendium on energy sources

Lamp

Skipping rope

Experiments:

- Box 1 – Sun panel of matches.
- Box 2 – Refrigerator experiment.
- Box 3 – Pinwheel.
- Box 4 – The crawling spool of thread.
- Box 5 – Electric car.
- Box 6 – Balloon race.
- Box 7 – Fruit watch.
- Box 8 – Exciting things.

Light box, blue

Teacher's manual

Experiments:

- The magic coin
- The mirror in the spoon
- Make a lens
- Tube oscilloscope
- Send beams
- Kaleidoscope
- Fibre optics
- The illusion pendulum
- Fly with a rocket to the moon
- Hole in the hand
- Make a rainbow

Light box, red

Teacher's manual

Experiments:

- Light in water?
- Make a magnifying glass of water
- To peek around a corner with a periscope
- Shadows
- Moving pictures
- Why are the sky blue and the sunset red?
- Fiberoptics
- Colour wheel
- Experience the world through prism glasses
- Afterpicture

Mathematics box

Teacher's manual

Books:

- Matte med mening (Math with meaning)
- Ska vi leka matte (Shall we play math)
- Räkna med mig (Count with me)

Games:

- Squares, hieroglyphs and smart cards
- Braham's tower
- 3D cubes
- Dime + work sheet
- Domino (addition and subtraction)
- One and ten
- Unity pyramid
- Ludo
- Hundred hunt (Tom's and Maria's numbers)
- How many snowballs?
- Kalaha (egg carton, 2 bowls, 36 be-ans)
- Hard candy + 6 game pieces
- Chain 1 and 2
- China checkers
- Cube fun + cubes
- Ruler
- Noughts and crosses
- 3D noughts and crosses
- Math with deck of cards
- Pencil case
- The pyramid
- Counting board + pieces
- Counting keys
- Game bag (with 9 pieces)
- Sticks
- Serrated scissors
- Tangram + worksheet
- Millipede (laminated + material for copying)
- Dice (3 regular + 2 ten sided dice)

Compendiums:

- Ideas for homework
- Symmetry
- Match problems

Space box

Teacher's manual

Books:

- Bamsebok/Resa bland planeter (Travel among planets)
- Runt i rymden (Around in Space)
- Rymdens gåtor (The riddles of space)

White, yellow and blue hat

Envelope with planet walk

Umbrella

Ping-pong ball

Space cassette-tape

The Big Dipper, experiment

Water box

Teacher's manual

Experiments:

- Lift an ice-cube without touching it
- Boil ice
- Underwater volcano
- Balloon with hot and cold…
- Can a needle of steel float?
- Water thermometer
- Hovering potato
- Siphon
- Diving-bell
- The Cartesian diver
- Mixes and solutions

C. Enkätfrågor om ditt samarbete med NAVET

1. Med vilken/vilka årskurs(er) har du varit på NAVET?

- □ F-2
- □ 3-5
- □ 6-9
- □ Gymnasiet

2. Vilket/vilka tema(ta) har du besökt med din(a) klass(er)?

- □ Digestiva
- □ Energi
- □ Flyg
- □ Kemi
- □ Ljus
- □ Matte
- □ Rymd
- □ Vatten

3. Hur mycket tid, ungefär, ägnades åt förarbete och förberedelse inför besöket?
……...

4. Lånade du med dig en låda efter besöket på NAVET?

- □ Ja
- □ Nej

Varför/varför inte? …….
……...
……...

OBS! Om du inte lånade med dig en låda kan du hoppa direkt till fråga 14.

5. Hur många gånger användes lådorna under lånetiden?

- □ 0
- □ 1-4
- □ 5-10
- □ >10

6. Användes allt i lådorna under lånetiden?

□ Ja
□ Nej

Varför/varför inte? …….
……...
……...

7. Tycker du att lådornas innehåll kändes relevant efter ett besök på NAVET?

□ Mycket relevant
□ Ganska relevant
□ Lite relevant

8. Är lånetiden tillräckligt lång?

□ Ja
□ Nej

9. Kände du att du behövde låna om lådan för att hinna med allt?

□ Ja
□ Nej

10. Tycker du att informationen i lådorna var tillräcklig?

□ Ja
□ Nej

11. Var informationen lätt att ta till sig?

□ Mycket lätt
□ Ganska lätt
□ Inte alls lätt

12. Tillför lådorna något till undervisningen?

□ Ja
□ Nej

Om ja, på vilket sätt/om nej, varför inte? ……
……...
.....

13. Upplever du att det är någon stor skillnad på de olika lådornas uppbyggnad (om du lånat flera)?

□ Ja
□ Nej

Om ja, vad är skillnaden?……...
……...
……...

14. Hur mycket tid ägnades åt efterarbete och bearbetning av besöket? ……...
……...

15. Har besöket på NAVET gett dig några tips till att förändra dina lektioner?

□ Ja
□ Nej

Varför/varför inte? …….
……..
……...

16. Har dina elever visat mer intresse för drama, spel och experiment på skoltid efter NAVET-besöket?

□ Ja
□ Nej

17. Har eleverna kommit med egna förslag på hur de vill ha lektionerna?

□ Ja
□ Nej

Om ja, beskriv… ……
……...
……...

18. Har du märkt någon förändring i skolans materialinköp sedan samarbetet med NAVET startade?

□ Ja
□ Nej

Förändring eller inte - vad beror det på, tror du? ……
……...
……...

19. Tycker du att samarbetet med NAVET varit givande?

□ Ja
□ Nej

Varför/varför inte? ……
……...
……...

20. Vill du åka till NAVET eller andra science centers med klasser igen?

□ Ja
□ Nej

Om ja, har du något speciellt i åtanke? ……
……...
……...

21. Vill du själv åka tillbaka till NAVET eller besöka andra science centers?

□ Ja
□ Nej

Om ja, har du något speciellt i åtanke? ……
……...
……...

22. Tycker du att ett science center är ett bra komplement till skolans undervisning i naturvetenskap och teknik?

□ Ja
□ Nej

Varför/varför inte? …….
……...
……...

Övriga kommentarer?

Questionnaire about your co-operation with NAVET

1. With what grade(s) have you been to NAVET?

- □ Pre school-2
- □ 3-5
- □ 6-9
- □ Upper secondary school

2. What theme(s) have you visited with your class(es)?

- □ Digestiva
- □ Energy
- □ Aviation
- □ Chemistry
- □ Light
- □ Mathematics
- □ Space
- □ Water

3. How much time, approximately, did you spend on pre-visit work and preparation?

……...

4. Did you borrow a box after your visit to NAVET?

- □ Yes
- □ No

Why/Why not? ……..…….
……...

N.B.! If you didn't borrow a box you can skip directly to question no 14.

5. How many times were the boxes used during the borrowing time?

- □ 0
- □ 1-4
- □ 5-10
- □ >10

6. Was everything in the boxes used during the borrowing time?

- □ Yes
- □ No

Why/Why not? ……...…….
……...
……...

7. Do you think the content of the boxes felt relevant after a visit to NAVET?

- □ Very relevant
- □ Quite relevant
- □ Not very relevant

8. Is the borrowing time long enough?

- □ Yes
- □ No

9. Did you feel that you had to borrow the box again to have time for everything?

- □ Yes
- □ No

10. Do you think the information in the boxes was enough?

- □ Yes
- □ No

11. Was the information easily understood?

- □ Very easy
- □ Quite easy
- □ Not at all easy

12. Do the boxes bring anything new to the lessons?

□ Yes
□ No

If Yes, in what way/if No, why not? ……
……...
.....

13. Do you feel there is any big difference in the structure of the different boxes (if you borrowed several)?

□ Yes
□ No

If Yes, what is the difference?……...
……...
……...

14. How much time was spent on post-visit work and processing after the visit?....
……...

15. Have the visit to NAVET given you any suggestions for changing your lessons?

□ Yes
□ No

Why/Why not? ……...…….
……..
……...

16. Have your pupils shown more interest in drama, games and experiments after the visit to NAVET?

□ Yes
□ No

17. Have your pupils come up with own ideas on how they want their lessons?

□ Yes
□ No

If Yes, describe……….
……...
……...

18. Have you noticed any change in the school's buying of material since the co-operation with NAVET started?

□ Yes
□ No

Change or not – why is that, do you think? ……
……...
……...

19. Do you thing the co-operation with NAVET has been profitable?

□ Yes
□ No

Why/Why not? ……...…….
……...
……...

20. Do you want to go to NAVET or other science centres with classes again?

□ Yes
□ No

If Yes, do you have anything particular in mind?……
……...
……...

21. Do you want to visit NAVET or other science centres on you own?

□ Yes
□ No

If Yes, do you have anything particular in mind?……
……...
……...

22. Do you think a science centre is a good complement to schools' education in science and technology?

□ Yes
□ No

Why/Why not? ……...…….
……...
……...

Other comments?