INTERACTIVE EXHIBITIONS

The Use of Interactivity in Educational Exhibitions

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ABSTRACT

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The purpose of this thesis was to study the meaning and use of interactivity in educational exhibitions. The theory was explored first, clearing the idea of what interaction truly is and how it is used in museums and science centres. New ideas and suggestions from several different experts were also viewed and advantages and disadvantages of different interaction styles examined.

The second part of the thesis was the research. The purpose of the research was to find out what level of knowledge people have about astronomy as well as how they tend to behave in interactive situations in a science centre. The data was collected partly in New Zealand, partly in Finland. The results followed the lines discovered in the theory part further enhancing its credibility.

The third part consisted of creating concepts for an interactive astronomy exhibition. The concepts were supposed to be quite preliminary, but still give an idea about what type of concepts there could be in such an exhibition.

During the process of making this thesis it soon became clear that this field is very complex and mixes several different areas from human intelligent to sociological behaviour and common sense. It does encourage the professionals to try different things, though, and its diversity gives motivation to the creative people. There was not enough room in this thesis to go very deep into some aspects. This is why there would still be material left for several other Bachelor’s theses in this area.

Key words: interactive exhibition, science centre, edutainment

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1 INTRODUCTION

Interactivity is in fashion, now more than ever. In our everyday lives we constantly use interactive appliances and applications. It has become a second nature to us to employ cell phones, computers, tablets, etc. and we rarely think their background or evolution – unless they do not function properly. There is a countless number of different ways to pursue interactivity, and at present it is not anymore a question of *if* we should be using interactivity but *how* we should be using it.

In education and learning interactivity has become a proper teacher's pet. Simple lessons, where teacher lectures in front of the class are considered old-fashioned and sometimes even unproductive. Companies are constantly trying to create new computer programmes and devices to make learning more engaging and fun. Educational entertainment, edutainment for short, is already a big market and it seems there is no going back to the old non-interactive ways anymore.

This is also clearly visible in museums and science centres. In the old days people went to visit museums to see paintings and artefacts in rather quiet and static surroundings. Nowadays almost every museum offers their visitors at least an audio guide or some sort of a multimedia presentation. Information booths with computers or even some gadgets and gimmicks are also widely used, especially in science centres where whole exhibitions are often designed to be highly interactive.

Designing and producing interactive exhibitions is a lengthy task. It demands clear understanding about interactivity but also about human intelligence and comprehension as well as lots of common sense. In this thesis the aim is to explore the different aspects of interactive exhibitions, how they work and what to consider when planning to create one.

2 HISTORY OF INTERACTIVITY IN MUSEUMS AND SCIENCE CENTRES

The word "museum" originates from the Latin word "Muses" – the goddesses of the inspiration to the arts and science. A "museum" was therefore a place that was protected by the Muses and thus a great place to engage in studies or performing different types of these arts. One of these venues was the Musaeum in Alexandria, established sometime around 300 - 280 BCE. It was a place where scholars met and conducted their research. (Jochum 1999, 3.) Consequently, in our times the closest equivalent for such a place is a university.

Already in the ancient world the wealthy citizens entertained their visitors with their private collections, but the first public museums the way we understand them today did not appear until during the Renaissance. (E.g. Capitoline and Vatican Museums were established during this time.) The real boost for the museum culture came when the Age of Enlightenment started in the 18th century. Many of the most famous museums in the world today originate from this era, e.g. the British Museum, the Hermitage and the Louvre.

PICTURE 1. Part of the astronomy exhibition in the Deutsches Museum. While the display is mostly static, the telescopes on the rail of the second floor can be used to compare different magnifications. (Photo: Eeva-Kaisa Ahlamo 2012)

2.1 Dawn of interaction in museums

Proper interactivity in the museums was unheard of before the 20th century. One of the first museums using interactivity as part of their exhibition was the Deutsches Museum in Munich in the beginning of the 20th century. The visitor could push buttons and work levers to explore some features of the exhibits. The museum still engages the visitors in similar techniques, even if the level of the interactivity in many parts of the primary exhibition is not exceptionally high. (Picture 1.)

Tim Caulton (1998, 3) points out that the step from the earliest science museums to the most modern present science centres is rather straightforward. In the core of their meaning has always been the urge to interpret and explain, and thus the trend toward interactive exhibits is a natural extension of this tradition.

2.2 The short history of science centres

The first completely interactivity-based museum was the Exploratorium in San Francisco. It was founded by Frank Oppenheimer in 1969 and still attracts hundreds of thousands of visitors annually. The Exploratorium mixes “science, art and human perception” and has the mission to “create a culture of learning through innovative environments, programs and tools that help people nurture their curiosity about the world around them”. (Exploratorium.edu.) Nowadays there are several similar attractions around the world, even if the difference between a science centre and a science museum is often a line drawn on water.

The main purpose of a museum is “to collect, to conserve, to study, to interpret and to exhibit” (Bradburne 2004). This already makes a small cut between museums and science centres, but for the visitor experience the line is more vague. The normal perception of science centres includes the idea of something engaging. It is a place where it is not only encouraged to interact with the exhibits but in truth it is also expected if the visitor wants to get the most out of the visit. When people go to the museums to *watch*, the same people go to the science centres to *do*.

Many science centres, e.g. Exploratorium, call themselves museums. For a common visitor in such a case it is hard to tell if it is only because they mix art with science in their exhibitions or is there some other view behind this approach. Still, also museums do try to educate their audience by explaining and engaging the visitors to listen, to learn and to explore.

3 CHARACTERISTICS OF INTERACTIVITY

The word “interactivity” comes from the Latin words “inter agere” where the “inter” means “between” and “agere” means “to do, to act”. So literally “to interact” means “to act between”. Something acts between something, so there are at least two things which interactivity connects. These two things can be humans, but we can also have human-device or even device-device interactivity. The key concept is nevertheless the interactive event between the parts: one part does something and the other(s) react to this by doing something in response. This leads to the situation where the original parameters have changed and the event can be repeated with the new situation.

3.1 Different levels of interaction

There are several different ways and attempts to label the levels of interaction. These are mostly based on human-device -events, since interaction between humans is more explored in sociological researches and device-device -interaction is based on appliances designed and produced by humans, meaning they already have carefully planned interaction in their framework.

3.11 Roderick C.H. Sims and seven levels of interactivity

Roderick C.H. Sims (1994) introduced his seven levels of interactivity he had drafted for his paper “Virtual learning environments for multiplatform applications”. These levels help to explain the idea of interactivity and its depth. They are also useful when designing any kind of interaction, since the use of different levels in e.g. exhibitions can help to give rhythm and flavour to the visitor experience.

Sims’s first level is called **Passive Interactivity** (level 1). This means the most basic level of interaction: through an action (pressing a button, moving to certain direction, etc.) the user is directed to the next display of a sequence. This interaction is quite strict, since the user does not have other choice than to follow the pre-determined route of the plan. This is why overusing this level leads to dull and predictable scenarios. The Passive Interactivity is closely followed by **Hierarchal Interactivity** (level 2) which is most common interaction in different computer menus. At first, it seems more complex than Passive Interactivity, but in the end Hierarchal Interactivity is just another version of the first level. When the user opens the menu, he needs to decide which item to choose, which button to press. The selection becomes Passive Interaction when the programme leads the user to the next scenario, i.e. the page or event preprogrammed to the function.

Update Interactivity (level 3) starts to gain the level we normally consider to be "interactive". In this level the communication between the device and the user develops depending on the answers given. The device gives feedback to the user or updates the next scenario based on the results it got in the last communication from the user. Word games and quizzes are good examples of this, the computer knows if the given answer was right or wrong and can act accordingly. **Construct Interactivity** (level 4) is an extension to the level 3. It includes several stages and possibilities to select right or wrong before the end result will be verified by the device. An example could be e.g. a jigsaw puzzle game where the player needs to construct the puzzle completely before the computer considers the level passed (picture 2).

PICTURE 2. Sims's interaction levels work also in real life, not only inside computers. Construct Interactivity is the same, no matter if the example jigsaw puzzle is real or digital. (Picture: Ahlamo 2010)

Simulation Interactivity (level 5) is closely linked with the Construct Interactivity. The difference is in the way the parts can be lain correctly: in the level 4 each jigsaw puzzle piece can be positioned only right or wrong whereas in the level 5 there are more possibilities. An example could be a simulation of a factory, where the player can turn the different valves and vents seamlessly to find the best possible situation for the factory to work.

The next level according to Sims is **Free Interactivity** (level 6). This means relatively uncomplicated browsing of an area, e.g. through hyperlinks or hotspots. Many computer games use this level of interactivity. There is not any clearly set route to follow, but clicking the hotspots and exploring through the given area will produce answers to the problems given. The last level is **Situate Interactivity** (level 7) which gives the user the chance to transport his virtual self to another reality and interact with it freely. The examples include all the virtual reality worlds, e.g. Second Life or World of Warcraft.

3.12 Interactivity according to Terry Borsook and Nancy Higginbotham-Wheat

Borsook and Higginbotham-Wheat (1991) identified some common characteristics in their research about interactivity in instructional programmes. They included the following six: **Immediate response**, which gave the user instant feedback and did not force the user to wait (e.g. when clicking a button). **Non-linear access to information** where the programme adapts to the user's level of knowledge and does not force the user through hierarchical steps of information, but presents the data that is relevant for him. **Feedback** as proper feedback (as opposed to the immediate response): feedback needs to tell the user how to improve, not just tell if the answer was right or wrong.

Options to help the programme find out about the level of the user: the computer needs sufficient information to set the level and it cannot do that if the questions or tasks are too simple for evaluation. **Grain-size** refers to the length of time required before the user is allowed to act. Too long videos or animations that the user cannot skip compromises the learning progress. **Learner control** where the user can have some degree of responsibility about e.g. the pace of the process. This helps the user to set the parameters best for himself, even if the total learner control should and would stay within the computer.

3.13 The three engagers

James Bradburne, who has developed lots of different interactive exhibitions as well as written about and researched them, gives another look into labeling the levels of interaction. He states that a **hands-on** experience is normally the one people think of when they talk about interactive exhibitions. That means that in an exhibition there should be a good number of gadgets, levers and buttons to push, pull, rotate, construct, etc. to get people engaged in exploring. Something concrete to touch and feel. But that is not all. Richard Gregory, founder of the first hands-on science centre in Britain, adds **minds-on** aspect to the exhibits. This means the user needs to understand what is going on to finish the task. There needs to be some sort of challenge for the brain. Additionally, Jorge Wagensberg, museum director in Barcelona, speaks of **hearts-on** exhibits and thus brings the feeling into the experience: it is not enough for the task to include only the body and the mind. It needs to evoke the spirit of the user as well. (Bradburne 2002.)

3.14 Concrete vs. abstract – the use of the senses

Since the dawn of the computer era our idea about interactivity has changed. The concept of interactivity was really only taken in the use with the new communication technologies and hence was made to apply to the arts and other “old-fashioned” but effective subjects as well (Kiousis 2002). In the media field the concept is often restricted in interactive multimedia, the type of interactivity which is accessible through computers and other technological devices.

Human perception of the world is transmitted through the five senses: sight, hearing, touch, taste and smell. Our brain translates these sensations into experiences which we use to comprehend the reality. All interactivity relates to these senses. Tending to a garden, for example, gives sensory feedback to all senses: the gardener can see and touch the plants; he hears the bees and smells the flowers as well as tastes the fruit. His interaction is a full experience and the garden responds to his efforts by growing satisfyingly. The sensation is concrete as is the interactivity.

Compared to this, interaction in multimedia is somewhat limited. The interactive parts are normally not real (e.g. icons on the desktop) but digital and symbolic. This interactivity leans heavily on visual and auditorial responses only. The sensation of touch is normally limited to mouse, keyboard and touchscreen. Senses of taste and smell are non-existent. There are plans to broaden the spectrum and break limits of such abstract interaction (Meyerson 2012). Even if we are still quite a way off from the Star Trek replicators there is some future for the missing senses in digital interaction.

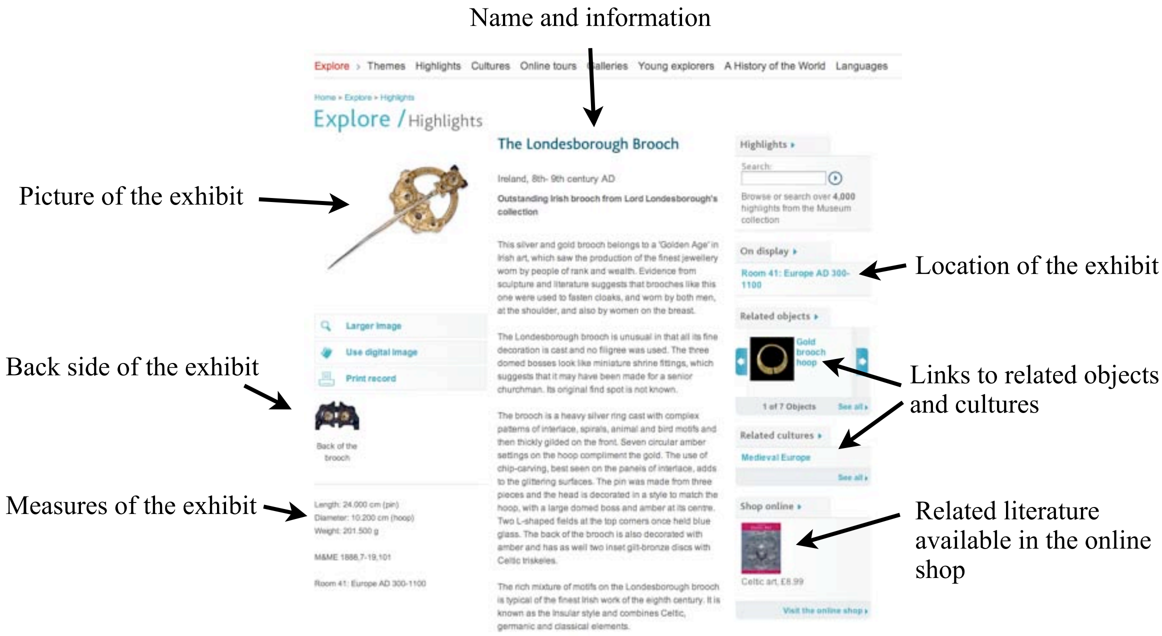
3.2 From education to edutainment

Why has interactivity become so attractive for the masses? What does it convey that cannot be extracted from the more conservative methods? On even more basic level, what is the meaning of interactivity? What is it used for? When talking about museums and science centres the answer is education. We go to exhibitions to find out about things. We are curious about the arts, history, science, etc. and we want to learn where the things stand in the big picture. Both museums and science centres are premises where we can pursue our interests and learn new things. Even when their basic purpose would be quite similar, there are often big differences in the ways they convey their message.

Anyone who has ever visited a science centre knows how chaotic places they can be. Children are laughing and running, machines are banging, people are talking and gathering around the exhibits, videos and audios are playing, gadgets are moving and rolling. The feeling is exhilarating and the visitor does not feel like he needs to suppress himself. On the other hand, when the visitor enters a typical museum the first sensation of the place is often stillness. People talk quietly or whisper to each other, they move slowly from one exhibit to another. If there are computers or other interactive elements they are often used by just one or two persons at one time. The feeling is much more static than in a science centre, here the visitor is a spectator. Learning happens by looking and reading, not so much through touching and thinking.

3.21 Abstract interaction and conservation in museums

Nowadays many museums have some interactive parts built into their exhibitions. Often these are just computers that the user can employ to gain more knowledge about the objects and pieces of art in the form of pictures, films and informative texts. Creating such digital copies of the museum exhibits reaches over the boundaries of the place and time since they are often available also on the Internet. Digital interaction conserves the exhibits even when the original pieces are not present (Hamma, 2004). For example on the homesite of the British Museum (UK) the visitors can browse through the collection highlights. Exhibit information includes which gallery it belongs to as well as its position in the floor plan and links to the related objects (picture 3). These create a sense of space and help the user to think of the real object in the real British Museum – and forget that he is actually seeing just the digital copy of the object in question.



PICTURE 3. An exhibit item on the homesite of the British Museum. (Picture: British Museum 2012, www.britishmuseum.org)

In many museums the interactive information is more academic than experimental. It is mostly supplementary details given to tell more about the objects in display and their relation in the world and its history.

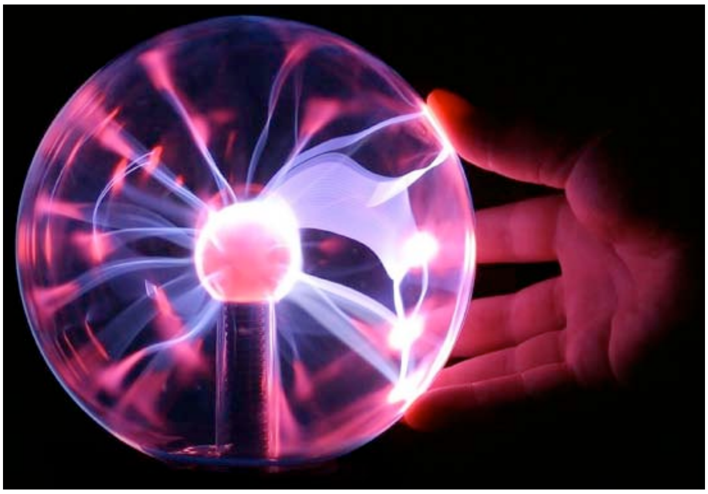
3.22 Group interactivity in science centres

Compared to the abstract interactivity in many museums, science centres play completely another role. They have been built to engage the visitors in interaction. The whole idea behind science centres originated from the need to make museums' way of educating more comprehensible and exciting (Bradburne 2004, 79).

One factor that is especially depicting for science centres is that visiting them is almost always a collective event. Sure there are also individual visitors, but most of the guests arrive with their school groups, friends, partners and / or families. This means they already have a platform in their group where they can reflect ideas, feelings, theories, etc. There will be a lot of interaction going on in these groups when the visitors evaluate, make decisions, converse and move around in the premises. The key motivation is to spend quality time with family and friends and to promote intergenerational learning as well as to strengthen family bonds and consolidate the family's sense of identity. (European Network of Science Centers... 2008, 7.) This naturally means that the exhibits should be planned so that they encourage joint exploration as well as cooperation between the users to gain the best results.

3.23 "What are they supposed to learn?"

Plain interactivity in itself is not yet enough. The exhibits at hand must also be engaging as well as clear enough for the message to come through. Bradburne mentions that many science professionals at the time stated that "the cognitive learning aspect wasn't important, it was the affective experience that mattered" (Bradburne 2004, 79). So, the question of the taste remains: is the meaning of interactivity in exhibitions just to explain one thing as coherently and comprehensibly as possible or is it to create the sparkle that will encourage the users to find out about that one thing and more related things later on in their lives? And has the exhibit failed if its only purpose for the visitor is to entertain him? A plasma ball is a good example of this. It is a very common and popular attraction in the science centres. It reacts to the touch and creates pretty patterns, but to really grasp what is going on the visitor needs to have a great understanding about different states of matter, electricity and gas – the full explanation is often omitted or the visitors will not read it. Thus the learning curve stays within the reaction to the touch and pretty patterns. (Picture 4.)



PICTURE 4. A plasma ball. (Picture: Wikimedia Commons)

Measuring the educational impact an exhibition has on the visitors is also demanding, particularly because science centres are not schools and the visitors should not feel like failing in the given tasks. In 1989 Drew Ann Wake conducted a study where she found out that the visitors in the Canada's largest science centre spent mostly only less than two minutes by the different exhibits and rarely completed the tasks given. These results made Bradburn to think of ways to reform the habit from just *showing* the things to people into encouraging them to *engage* with the exhibits. (Bradburne 2004, 73.) This means that no exhibit should instantly reveal its meaning, but only to disclose their contents and functions through the active intervention of the viewer.

Drew Ann Wake and James Bradburne have been conducting a lot of research together, underlining these original discoveries and trying to find more innovative ways to bring interactivity in museums. Their work is not completely without criticism, though. Joe

Ansel claims in his paper about experiential exhibits that Wake and Bradburne expect too much of science centres, since they are just adjuncts to schools, universities and libraries and they are not designed to replace these educational resources. This is why the information emitted through science centres does not need to “convey scientific information to the general public as a professional scientist might understand it”. (Ansel 1996, 8.)

There has been a long debate about the role of science centres and especially the way how they promote the image of the science for the public. The centres might give the false idea about scientific inquiry leading to instant solutions, when in reality the scientifical discoveries are often the result of very tedious and long work. (Caulton 1998, 17.) In the end, though, the question is mostly rhetorical, because the answer depends totally on the person’s opinion about the role of science centres in the society.

4 HOW TO LEARN

People are different. They perceive the reality in different ways and they also have various ways to best understand and memorise things. This is the reason why it is so tricky to plan educational material: how to make it so that everyone gets the best out of it with the smallest possible trouble.

Science centres and interactive museums provide an extra challenge for exhibition planning since their visitors are all in very different levels of learning. Some do not have any previous knowledge about the subjects, some are experts in the field. Still, all wish to face challenging and entertaining situations while learning something new on the go. (Here challenging means an action that forces the user to think deeper or act in a new way to solve problems and achieve feelings of succeeding.) There are different ways to give tools for the visitors to reach these goals. Normally they rely on the ways of how people prefer to learn.

4.1 Different intelligences

Different learning techniques and their use in education is a vastly debated subject and there is plenty of critique about its accuracy (Coffield, Moseley, Hall & Ecclestone 2004, 55). Still, there are some theories that have been around longer than most and browsing through them does give some food for thought and maybe inspiration when planning interactive exhibits or some other related material. Basing the exhibits to different learning styles could give more chances for everyone to find their favourites among the gadgets. If there are enough resources, it might be a good idea to do like Joe Ansel (1996, 5) suggests: “... we were building multiple examples of the same, and related, phenomena; thus if one exhibit didn’t provide what a particular visitor wanted, another would.”

4.11 VA(R)K

Jessica Utts (2008) from University of California (US) presents some of the different learning styles, their statistics and possible use in education. The most famous is **VA(R)K**, which labels the learner's preference for taking in and giving out information in three or four different categories. They are the *visual*, the *auditory* and the *kinesthetic* learners plus the *readers* and *writers*. People often have characteristics from several or all categories and it is possible to use the preferences separately or together. When needed, some people

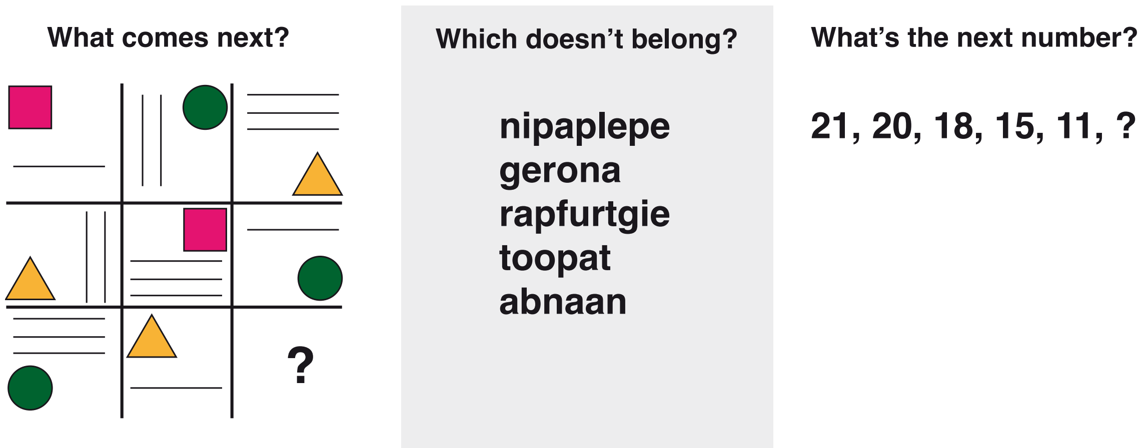
> examine the situation and choose the preference that suits that situation. They could be described as *'context specific'*. Others need to use *all* their preferences to get an understanding that suits their learning needs. It could be said that they are *'context blind'*. Although they take longer to *'understand'* something new, their understanding is deeper and they have wider perspectives. (Fleming 2011.)

VA(R)K is not a proper learning style in the sense that it focuses only on the ways in which people like information to come to them and how they like to deliver it further. It does not say much about personality, motivation, social preferences and other parts that create a full learning style. If someone has difficulties to concentrate in a classroom full of noisy children, no amount of VA(R)K will make him a celebrated genius in such surroundings.

4.12 The theory of multiple intelligences

Another way of exploring ways of learning are **the multiple intelligences**. Nowadays the agreed number of them is eight. They are *linguistic, logical-mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal* and *naturalist.* Linguistics are good with words, reading, writing, etc. Logical-mathematicals can discern logical / numerical patterns. Spatially intelligent understand and manage the visual world and perceive it as pictures. Bodily-kinesthetic are good at using their physical abilities to solve problems. Musically talented are naturally good with instruments and singing. Interpersonals are good with social skills when intrapersonals understand well their own emotions and desires. Naturalists have “the green thumb” and they are good in understanding natural phenomena. (Davis, Christodoulou, Seider & Gardner 2012.)

Employing multiple intelligences in e.g. classroom means trying to engage different styles of learning in order to maximise educational success and enthusiasm among diverse learners. This gives the pupils the chance to use their skills also in those areas which are not necessarily often used outside the respective subject lessons like music and sports. (Picture 5.)



PICTURE 5. The IQ tests often focus only on logical-mathematical and sometimes linguistic intelligence. This means that the measured IQ represents just those parts of human intelligence and does not necessarily give realistic picture of the person’s abilities. (Pic: Ahlamo 2013)

4.13 Felder/Silverman and the search for the median

Felder/Silverman’s approach to learning styles creates lines between opposite ends and calculates in which end or how in the middle the learner stands. The opposing characteristics include *sensing vs. intuitive, visual vs. verbal, active vs. reflective* and *sequential vs. global*. A study conducted at Ohio State University shows the graphs for over 2000 students. About 2/3 of them considered themselves more sensing than intuitive, meaning that thinking is more concrete and practical than abstract or innovative. About 3/4 was visual more than verbal. In active vs. reflective the game was almost even, but slightly more were active than reflective. This means they learn better by trying things out than reflecting them fully through. Active learners also enjoy working in groups and discussions. About 7/10 was sequential, meaning that they worked with the problems in small steps and with pieces of information at the time and did not think about the big picture while performing the tasks. (Utts 2008.)

4.2 What can be expected from the visits to museums and science centres

Since one of the tasks of the science centres and museums is to educate their public it is clear that the measure of a good exhibition are the lasting benefits and the frequency which with the visitors are able to remember subject-related information after their visit. Many studies have shown that there is at the very least a short-term increase in the range and depth of visitors' conceptual understanding. Things experienced in the science centres and museums are actively interpreted by the visitors, e.g. pupils, and incorporated into their existing mental models. This differs from the passively accepted textbook information that is often so common in schools. (European Network of Science Centers... 2008, 3.)

4.21 Generic learning outcomes

Going deeper, the Museums, Libraries and Archives Council (MLA) has presented a taxonomy of five types of learning outcomes. This list has become the standard definition of educational benefit for museums in England and is used by a growing number of science centres, too.

The MLA's generic learning outcomes

- *Knowledge & understanding:* Learning facts or information; Making sense of something; Deepening understanding; Learning how museums, archives and libraries operate; Making links and relationships between things, Using prior knowledge in new ways
- *Skills:* Intellectual skills – reading, thinking critically and analytically, making judgement; Key skills – numeracy, literacy, use of ICT, learning how to learn; Information management skills – locating and using information, evaluating information, using information management

systems; Social skills – meeting people, sharing, team working, showing an interest in the concerns of others; Emotional skills – recognising the feelings of others, managing feelings; Communication skills – writing, speaking, listening; Physical skills – running, dancing, manipulation, making…

- *Attitudes:* Opinions about ourselves e.g. self-esteem; Opinions or attitudes towards other people; Attitudes towards an organisation e.g. museums; Positive and negative attitudes in relation to an experience; Reasons for actions or personal viewpoints; Empathy, capacity for tolerance (or lack of these)
- *Enjoyment, inspiration, creativity:* Having fun; Being surprised; Innovative thoughts, actions or things; Creativity; Exploration, experimentation and making; Being inspired
- *Action, behaviour, progression:* What people intend to do (intention to act); What people have done; A change in the way that people manage their lives including work, study, family and community contexts; Actions (observed or reported); Change in behaviour; Progression – towards further learning, registering as a library user, developing new skills – is the result of a purposive action which leads to change (European Network of Science Centers... 2008, 12.)

As seen from the list, the role the museums and science centres have taken for themselves is to educate and raise the generations. Very rarely a visit to a museum can create life-lasting effects on the visitor, but it might just give a new idea or way of thinking that can then be used in some other situation. Naturally it is impossible to trace any specific thoughts back to a visit in a museum years ago, but the museums and centres nevertheless try to give the tools for eager people to use for enhancing their lives by knowing more about society, sciences, etc.

4.22 Social capital

A great experience of a visit in a science centre brings with it not only the learning but also the social aspects. All kinds of cooperation while solving the tasks and problems add to the social capital. It helps to take in consideration ideas from other people and strengthens the bond between humans while giving the chance to understand the way the other person thinks. (European Network of Science Centers... 2008, 14.)

Leisure experiences with a family as a child have also been proven to raise the interest towards museums in individual persons much more than a visit with a school (Caulton 1998, 23). Positive experiences in the childhood will encourage the people to return to the museums throughout their whole lifetime, later with their own families. This means it is also vital for the distant future of the museums and science centres to make their exhibitions today as captivating as possible.

5 DIFFERENT APPROACHES

There are naturally several different ways to try to get people engaged with the exhibitions, and the whole shebang about interactive exhibitions is based on finding the best ways to get the exhibits truly interactive. The various aspects to take in consideration include profiling the visitors as well as finding out what works in view of interaction. Pedagogy is the stage of this act and human behaviour plays one of the leading roles.

5.1 Human behaviour

People are curious. When they encounter something they do not quite understand or see something that might pose a challenge, it is usually enough to get them going and trying to resolve it. (This is the base and reason for all sciences.) Pedagogy is a science of its own and there is not enough room in this thesis to go through all the possible variations on the subject. The basics are nevertheless very simple: To get people interested in something there needs to be certain motivation to make sure they pursue it to the end. People sometimes talk about “a sparkle” that they have gotten from an inspirational documentary, presentation, sermon, event, and so on. Sometimes this sparkle lasts for few minutes, sometimes for a lifetime.

When it comes to science centres and museums, the ways to generate the interest are all inside the same premises. To get the visitors enthusiastic about learning there needs to be active engagement involved throughout the exhibition. Eilean Hooper-Greenhill listed the following outcomes as being important indicators of engagement: persistence, asking questions, creativity, asking another’s support, making one’s own definitions and “show and tell”. These methods are all highly desirable in any interactive exhibition. (Bradburne 2002, 3.)

Such “learning by doing” will naturally give a huge responsibility for the museums and science centres in relaying the truth as accurately as possible. Common people need to be able to trust in the objectiveness of the museum institution, since even the slightest doubt behind the reasons can lead to confusion and frustration – not only during the visit but also in the status of the establishment in the society (Bradburne 2004).

5.11 Planning for visitors

Tim Caulton (1998) points out that typically half of the visitors of interactive exhibitions in science centres are adults. They play a key role by assisting the children. Thus, if the adults feel uncomfortable, they will tend to draw children on to other activities. After researching appropriate learning theories Caulton has created a list of some prospects that would be good to include in an interactive exhibit. He says that the exhibits should

1. Have direct and obvious actions and reactions.
2. Have clear goals, expressed in terms of encouraging visitors to develop physical skills, to improve their knowledge or understanding, or to refine their feelings and opinions (i.e. psycho-motor, cognitive and affective outcomes).
3. Are intuitive to use and require minimal label-reading.
4. Work at multiple intellectual levels, for visitors of different ages and abilities.
5. Encourage social interaction between friends and family members.
6. Have open-ended, variable outcomes.
7. Are founded upon research into the existing knowledge and understanding of targeted visitors with a wide range of interests and learning styles.
8. Are challenging but not threatening to visitors, and which help to build confidence.
9. Provide enjoyment for visitors, and leave them feeling they have understood something more than they did previously.
10. Are well-designed, safe, robust and easily maintained. (Caulton 1998, 28.)

One of the things to keep in mind while starting the planning of an exhibit is to consider how much the user must already know about the subject. Especially in the science centres this subject can be e.g. physics – a field which many visitors at first glance might find complicated and hard to grasp, especially if there are many years between the physics lessons taken at school. Then again, just entering premises where there most likely will be lots of information about physics the first step is already willingly taken. To help engaging, the exhibits should always have some connection with everyday life or at least explain where the phenomena of the exhibit can be used or seen.

5.12 Family as a unit

One of the core visitor groups and typical customers in interactive exhibitions is families. Indeed, in the survey done in four Scottish science centres in 2008-2010 the total of family visitors (i.e. individuals making a visit as part of a visitor group that includes accompanied children under 16 years of age) was over 70 per cent (Morris Hargreaves McIntyre 2011, 12). With such family visits, there are some patterns that repeat themselves, even if conclusive evidence is tricky to gather. Certain patterns in family visits are following.

1. Family visits to museums are informal, unstructured occasions, rarely planned more than a day in advance, which provide a pleasant opportunity for members to strengthen family ties.
2. Families come with their own agendas, but these are likely to include learning in an informal environment (i.e., combining entertainment and education).
3. Families behave remarkably consistently in different types of museum, in both North America and Europe.
4. Families behave like window-shoppers, browsing until they see something that attracts them.
5. Parents are most likely to choose the area to explore, but children are more likely to select individual exhibits.
6. Most families do not read labels before interacting with hands-on exhibits.
7. Children are more likely to interact than adults, and adults are more likely to read labels.
8. Family behaviour and learning is influenced by the type of exhibit and by the stage in the visit at which an exhibit is encountered. (Caulton 1998, 25.)

There are naturally other visitors, not just families, but some of the patterns nevertheless repeat throughout the audience. In a sense, it could be useful to consider most of the visitors as “families”, where e.g. a school teacher takes a role of a parent when the pupils play the role of the children. Or where similar interests and curiosity to combine entertainment with learning new things mold the behaviour of couples and friends, even if they are not families with children.

5.2 Keeping up appearances

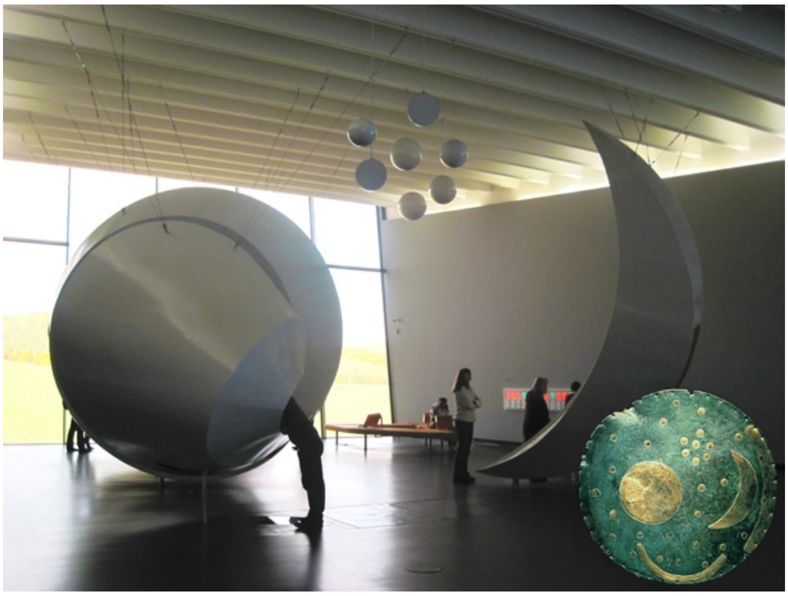
The museum or the science centre decides what is important enough to be presented or showed. It shapes the visits with its decisions about architecture, floor plans, exhibits, lighting, possibilities, etc. There is a huge number of choices to be made before the exhibition is to be opened for the public. These choices create the user-language of the place. Why is this presented this way? Why is that placed next to this? There are hidden meanings in everything, and the visitor will interpret the decisions in their own way.

5.21 User-languages

James Bradburne states that the exhibit's user-language is the single most important part of the exhibition. It describes what will be included and what is made invisible. The most important user-languages for any given interactive exhibition are *textual authority*, *observation*, *variables*, *problems* and *games*. The user-language allows us to describe and analyse the exhibit in terms of its content and its intent. For instance, the way an instructive text is written can give a distinctive feeling about the exhibit and the means it is supposed to be used with. (Bradburne 2002, 6.)

When the visitor lands at an exhibit the first thing he sees should be a clear user-language. The setting should give enough information about what should be done first and certain hints about what is going to happen when the first thing has been successfully finished. (Picture 6.) There should not be too many actions or possibilities that would only confuse the user. One of the ways to guide the user is the "textual authority" that Bradburne (2002, 6) mentions in his text. This means there is information – most commonly text – that is given in the third person. It is the voice of authority and it is not to be questioned.

Another way of building user-language is to use observation. This is often seen in science centres. They encourage the visitors to try things out and watch what happens. The user can observe the results of his work. He can feel like being in control, even if the outcome is almost always the same, no matter who turns the wheel, presses the



PICTURE 6. Arche Nebra (Saxony-Anhalt, Germany) explains the story of Nebra Sky Disk (picture above, lower right). When entering, the visitor might notice that the whole exhibition is symbolically just that: diving into the sky disk itself to research it piece by piece – just like the presentation suggests. (Picture: Ahlamo 2011)

button or pushes the lever. By grouping several different observations we can also talk about the user-language of variables. In these three user-languages the role of the visitor is predetermined. The museum or the science centre has decided what it is that needs to be found out, which observations to make. But “if an exhibit forces the user to a predictable conclusion, often no genuine personal discovery occurs.” (Ansel 1996, 2).

In the user-languages of problems and games the possibilities grow exponentially. They give the user free hands to decide how to go with the exhibits and often hint or show just the end result(s) that they should try to reach. They support the visitor’s attempts to define, analyse, solve and to compare the merits of different formulations. When planning these kinds of exhibits the designer should keep the core idea in his mind all the time. The exhibits cannot be so complicated that the user forgets or does not understand what is the idea behind it or what is he really supposed to learn from it all.

The overall user-language of any one place should always stay pretty much the same. It is confusing and frustrating for the visitor if the user-language changes all the time between different exhibits. Some changes are acceptable, but they should always stay justified and understandable.

5.22 The next generation

Since the opening of the first science centres few decades back there has been more and more of them appearing around the world. Exhibitions have been produced, new things have been learned – mostly with trial and error. Some older interactive museums have very old-fashioned exhibits, some more modern centres boast with high-tech gadgets. The field is constantly in motion when new things are being tested and discarded or accepted.

James Bradburne (1989) talks about different generation museums and science centres. The first generation is the look-and-learn style of labeling and cataloging the scientifical information. There is not much interactivity in the sense we often talk about it. The visitors can engage only by studying dioramas or pushing a button, “just enough to set in motion the re-enactment of a fundamental truth” (Bradburne 1989, 3). The second generation is the generation of the science centres like the San Francisco Exploratorium and many other “modern” centres. They entertain the visitor with innovative interaction and involvement, but even here the action is still mainly just following a predetermined path to reach a predictable goal.

Bradburne (1989, 5) calls the third generation “Beyond Hands-on” and explains how it should break the norm of the current science centres and interactive museums by giving free hands for the visitors. To really get people engaged in science, they cannot eternally be taught the known principles even if it was fun. It may raise the interest in science, but it does not guarantee that the user really understands how the principles work together or what is their role in the world we live in. This is why the third generation science centre would need to be built on four different approaches: doing science, making connections, variety and coherence.

With doing science, instead of just presenting the known principles of science it should be shown as an ongoing process where the people could genuinely participate (Bradburne 1989, 6). This would give them more understanding about how the scientific world functions and give reasonable doubt about the things we consider to be the truth. Connection making would encourage the visitors to look for answers also from the unconventional directions. One of the known problems in the present science is the lack of interdisciplinary theorems and methods to find new approaches to the research.

Variety means that the third generation science centres should create hybrid exhibits that could be recombined, reassembled and recreated regarding the needs (Bradburne 1989, 6). The premises should always be in a slight state of change to prevent getting stuck in its old ways of explanation or orientation. It should be a place of pulsating surroundings and let the visitors find it different over and over again. And with coherence Bradburne means that everything in the place should add to the visitor's experience. They should feel every part of their visit contributing to a total understanding about how science is done as a fundamental human activity. (Bradburne 1989, 7.)

This kind of approach does not only include the science itself. It takes into account also the moral, philosophical, political, etc. issues that can enhance the understanding about the role of these levels in the society. It is the act of making hypotheses and testing them, not really knowing where it is going to lead to. This teaches the visitors not only the science itself but also how it can be learned further, what ways there are to gain more knowledge and how to interpret the results. (Bradburne 1989, 7.)

6 DIFFERENT PARTS OF AN EXHIBIT

An exhibition is the sum of all its parts. There are several details that have to be taken in consideration before a proper result has been reached. Exhibits themselves are naturally a big part of it all, but also the surroundings play a role when it comes to the visitor satisfaction.

6.1 Exhibits

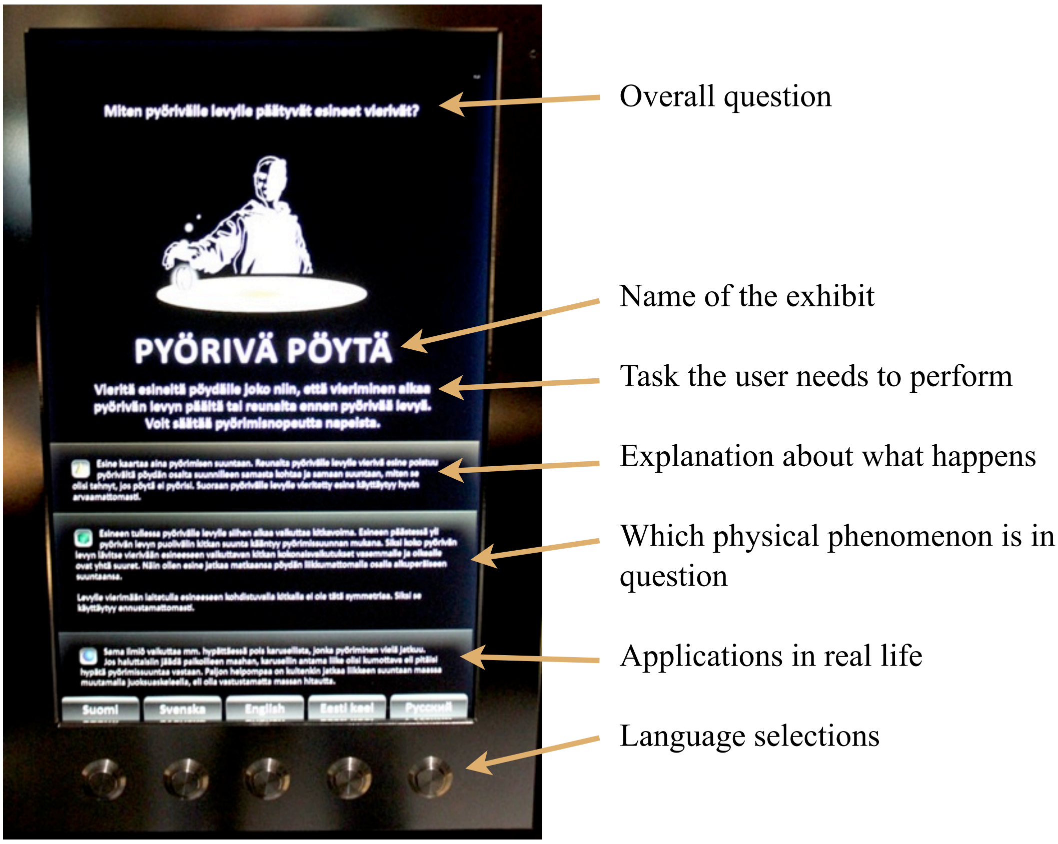
There are many things to contemplate when producing exhibits for exhibitions. Just creating a handsome or entertaining exhibit is not enough. There needs to be more to it, at least when planning a full-blown exhibition. Single exhibits also need to feed from their environment and the way they are presented in it.

6.11 Info texts

One of the most common ways for a museum or a science centre to communicate with their visitors are the information texts that tell the user what to do with any given exhibit. The information is supposed to give details about the object or instructions about what to do and what to expect from the exhibit as well as point out what is its relevance in the modern day world.

The role of the text should not be overly important, because especially in science centres many people will not bother to read it before they have already tested the exhibit. (See Chapter 8.2 Visit to Heureka – the Finnish Science Centre) This means the text should not be a requirement to engage with an exhibition, especially in cases where small children are involved (Caulton 1998, 30). It should be there, though, and be clear and consistent in its support for the exhibit itself.

For example in Heureka - the Finnish Science Centre, the information texts for the Heureka Classics -exhibition have all the same narrative. (Picture 7.) First there is a question or a synopsis about the phenomenon in question. This is followed by the task itself, explaining what the user is supposed to do. The task is written with the biggest letters and big marginals for it to be highlighted. The following smaller text is divided into three parts: first part explains what happens when the task is done and gives more ways to explore if there are any. The second part talks about the physical phenomenon behind the task and the third part gives examples of applications and use of this particular phenomenon in nature, science and technology.



PICTURE 7. Heureka Classics information text in Finnish language mode (Pic: Ahlamo 2013)

6.12 Reactive vs. interactive vs. open-end

Truly interactive exhibitions and exhibits are rare. Very often the action is limited into reactive performance. A button is pressed or a wheel is turned and the action follows. In many cases this might be enough, but when planning exhibitions it would be good to keep in mind that true interaction always communicates with the user. (See chapter 3.)

Again, it is important that the visitor understands what can be expected from the exhibit. He needs to be ready for the action when it happens, so that he can observe and draw conclusions. If the exhibit is genuinely interactive it offers the user new perimeters and asks him to move on within those limits. If there is no clear finishing line in the exhibit and the interaction can continue until the user wants to move on it is open-ended interaction.

Reactive action is often very short. It can truly be just pressing a button to release an action. Things to learn for the observer are also rather limited since the exhibit works normally only one way – either the button is pressed or not. In such a case the outcome should be clear and simple because the action is so uncomplicated.

Interactive exhibits need more flesh on the bones than plain reactive ones. There should be a goal for the user to reach in the end, e.g. a prize to grasp or some entertaining action to witness. It is closed interaction: there are several ways to reach the target, it is up to the user to select the path he wants to follow. Still, there are only so many ways to interact with the exhibit.

Open-end interaction does not necessarily have any given goal. I could be just exploring or communicating with the exhibit. This means there is also not necessarily any clear lesson the user can learn from it. It is there to give insight to some certain problem or an idea, or it can contain information about a completely new enigma.

6.13 Relation to the principle

As mentioned before one of the biggest tasks of the science centres is to let visitors explore and learn more about science, the arts, history, etc. This is why it should be priority to try to keep the exhibit's relation to any given principle as clear as possible.

No matter how complex or simple the use of the exhibit might be there should always be a trivial question behind it. This question should summon the common problem into as simple point as possible. If the question is posed cleverly the same question can be used as a basis with several different exhibits. This question is the narrative of the exhibit. It helps, if it can be something people face in their everyday lives. Exactly this relation to the normal world is vital for the best possible user experience.

Also the results should be given in the simplest form, something that the people can relate to their lives. For example, if we are trying to understand the scale of our Solar System we are in trouble. Human mind cannot understand distances like 150 000 000 km because they do not exist on our globe and they do not have any relevance in our lives. 150 000 000 km is the average distance from planet Earth to the Sun, in Solar System scale also called 1 astronomical unit (AU). When the two planets are closest, the distance from Earth to Saturn is roughly 7 AU. For common people these are just numbers, they do not really convey anything about the distance itself. It becomes more comprehensible if we translate it into another example: if we would take an airplane, e.g. normal Boeing 747, and if it would be possible to fly that to Saturn, it would take about 150 years to reach the planet. Even in the scale of our Solar System, Saturn is still relatively near. Pluto is more than five times as far as Saturn and even that far we are not even near the outer limits of our local region in space.

6.14 Mixed use of the interactive and non-interactive objects

It is not necessary for an exhibition that all of its exhibits are interactive. In science centres it might be partly expected, but in visitor and heritage centres it is very likely not even possible. If parts of the exhibition are non-active it must naturally be clearly shown. There should always be a real reason behind why certain exhibit is built to be “hands-on” (interaction on the level where some physical engagement is needed), it should not be done just because it is “fun”. If there is no proper reason, the exhibit can become confusing and disappointing.

One very important thing is also to make sure that the safety of the original “look only” objects will not be compromised if there are hands-on objects around. With well-planned distribution the active and non-active exhibits can support each other and give rhythm for the whole visit. They can be used to create a proper narrative, e.g. with the same techniques as dramaturgy uses.

As Caulton points out, not all hands-on exhibits are appropriate for all exhibition themes. In the end, the exhibits should not distort the historical or scientific discovery (Caulton 1998, 35). The exhibits should be planned tastefully, especially if there are sensitive subjects involved. If this is not possible it would be good to reconsider the whole meaning and existence of an interactive exhibit.

6.15 Narrative

To make the exhibition easier for the visitors to follow there should be a coherent narrative involved. This narrative can mean the way of distributing the exhibits around or the way they are supposed to be interacted with. It connects or separates the exhibits and it can be used to ease the understanding about what goes together and what not. A narrative could be a hint in which order the exhibits are supposed to be exhibited, e.g. in a heritage center where the local history is presented as a timeline. It could also e.g. scale the exhibits to be comparable, no matter of their location in the exhibition, e.g. hydrogen atom compared in the size to ethanol molecule in a chemistry display.

The narrative should not be overly highlighted, because too strong narrative may reduce the feasibility of concentration with the single exhibits. It is a good tool to get people curious and eager to move to the next spot if it is skilfully done, though. Proper narrative often serves as the theme of the exhibition, posing a common question or problem that describes the whole show.

6.2 Constructivism

The tricky part in making science interactive like it is usually done in science centres is that it implies there to be an ultimate truth that people will find if they just look hard enough and add enough supplementary information into the knowledge that they already have. In reality, though, the science as we know it today is in constant change when new theories and observations are published every day. Caulton talks about *constructivism* as the method of reorganising the personal knowledge as it comes when people interact with the world. (Caulton 1998, 37.)

When planning exhibitions this means that people should be encouraged to interact with those exhibits that they find relevant in their personal, physical and social context for the visit (Caulton 1998, 37). As a result, the exhibition should encourage people to draw their own conclusions about the exhibits and give them the chance to make the connections between different exhibits to develop their world view. This naturally proposes a huge challenge for the exhibition developers, since such exhibitions cannot clearly follow any given storyline, but creates an environment where all possibilities are created as hints and suggestions to find out more. It is like a huge task track where the results can only be understood and judged by the people themselves.

It is questionable, though, if it is a good policy to let people stay in their comfort area and not challenge them to try something completely new. It might feel nice to let people who are interested in e.g. chemistry try and deepen their knowledge in that field, but there is the risk it only strengthens the image of natural sciences as separate entities. This is exactly what should be avoided, since interdisciplinary methods are very important for sciences.

6.3 Premises

The exhibition as a whole is not limited to the single exhibits. The physical premises with the lighting, colours and materials are a big part of an exhibition as well as its narrative and instructions together with the overall appearance of the place. The target behind all this should always be the setting of appropriate goals for targeted visitors (Caulton 1998, 39).

6.31 Surroundings and architecture

The environment in the exhibitions is an important part when measuring the attraction and overall experience of the visit. People who arrive to interactive exhibitions normally expect to be entertained as well as educated. This is why it is good to try to build the surroundings catering the exhibits to enhance the social context as much as possible. This includes details like leaving enough room for gatherings of several people around the exhibits or placing the exhibits in such a form that the parents will not have much trouble in looking after their children (e.g. open spaces instead of lots of angles behind which the small children can disappear).

According to Caulton (1998, 27), the visitor orientation is a vital component of the communication between the exhibition and its visitors. There are four different orientation ways: *geographical* to guide the visitor, *psychological* to stimulate the mind, *intellectual* to encourage understanding the content and *conceptual* to help develop ideas. It is good to notice that these four ways play their role as much outside the exhibits (in the form of the surroundings) as inside them. The premises need to help people to concentrate in each single exhibit. If this is not the case, the learning experience is likely to be compromised.

6.32 Physical plan of the exhibition

There has been concern about how effective interactive exhibits truly are. In many studies the amount of time spent by the exhibits is often too short to suggest that any proper learning would have happened (Bradburne 2004, 73) (Ansel 1996, 1). There can naturally be several reasons why people will not spend longer time periods by the exhibits. They might not understand what is expected, they might not be interested in that particular science or it might just be too dull. Still, surroundings do play a big role. If the exhibit demands concentration from the user, other loud exhibits nearby might create a challenge to truly focus on the exhibit. Especially children have difficulties in concentrating in one place for a long time if there are other interesting looking things around. In big spaces this might lead to a “pinball effect” where the children run around the space checking the gadgets but not engaging with them too deeply. (Caulton 1998.)

There are ways to try to prevent this problem. Especially science centres often have big spaces where there are several exhibits placed in the same area. When this is the case, the characteristics of the exhibits should differ a lot from the others nearby. The bigger exhibits draw the attention the moment the visitor walks into the hall and they are the ones which are often checked first. When the curiosity with them has been fulfilled the visitor turns his attention to the smaller gadgets. Completely different functions between the exhibits can keep up the interest and engagement and help to create rhythm and narrative for the exhibition.

Another way to build exhibitions is to – instead of a big hall – guide the visitors through a corridor where the exhibits follow each other in a continuum. This helps the people to concentrate in any given exhibit since there are not that many other disturbing noises, movements and distractions around. This is a challenging way to build the exhibitions, though, because avoiding queues and frustration when there are several people browsing through the exhibition might turn out to be impossible unless there is room for as many people as possible by the exhibits. (Picture 8.)

PICTURE 8. The Ames Forced Perspective Room in Puzzling World, Wanaka, New Zealand. There is plenty of room for several people and there needs to be at least two people for the optic illusion to appear. (Picture: Ahlamo 2007)

6.33 Lights and colours

Colours and lights are also important part of the premises. They can help people to perceive different parts of the exhibitions or guide them subtly to right directions. They can help the space to feel dynamic and easily approachable.

There are several ways to use lights. Ambient lighting provides general illumination and is often done with indirect lighting, because it gives the feeling of spaciousness. Accent lighting is often decorating. It turns the focus on the objects and can thus emphasise their meaning or create drama. Task lighting illuminates areas where certain action is supposed to happen. (Karlen, Benya & Spangler 2012.)

The colours can be used to stimulate the visitors. Warm colours with longer wavelengths (red, orange, yellow) are often considered to be “active” colours when the cool, short wavelength ones (blue, green) are more static or sedate. Different studies point e.g. the colour red to be active, adventurous, stimulating, energetic and vital when yellow is sometimes mentioned to stimulate the intellect. Blue and green are considered relaxing and peaceful. (Bellizzi, Crowley & Hasty 1983.) Colours are a good way to make distinction between different parts of exhibitions. They can also be used to help the narrative by pointing out which parts belong together and which are separated.

6.34 Associated premises and surroundings

Exhibitions themselves are not the only part of visitor, heritage or science centres or museums. Cafés, restaurants, shops, garderobes, toilets, etc. play also a critical part in a positive visitor experience. These parts should be designed to enhance the feeling of being linked together and they should help the visitor to reach the orientation as well as help to understand how the premises work. Aimless moving around (caused by e.g. badly placed garderobes) should be avoided because it can create tension during rush hours like e.g. school holidays.

7 INTERACTIVITY VS. COMMUNICATION

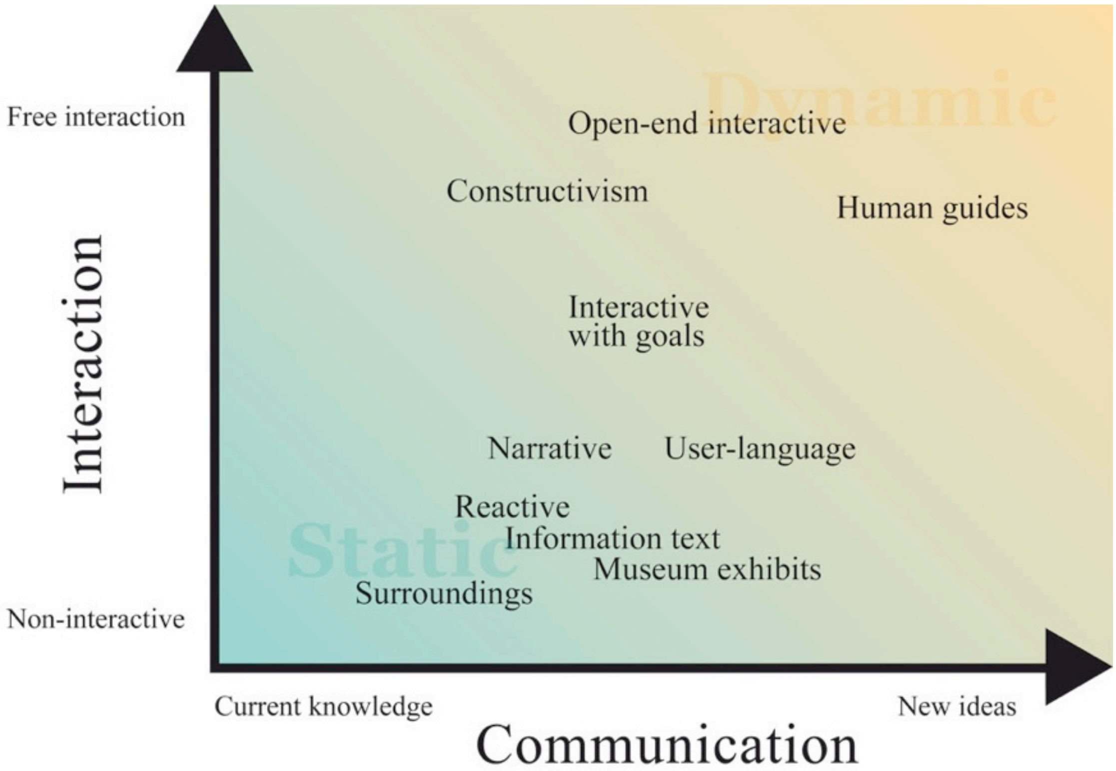


FIGURE 1. Interaction-communication diagram

This diagram (figure 1) compares interaction and communication, the two most important parts of interactive exhibits. The main questions with any given exhibit are “How well does it communicate its purpose?” and “Is it truly interactive?” Here the different approaches to interactivity have been presented in a chart.

What a person brings with him into an exhibition is his current knowledge and the readiness to engage with the exhibits (but his present state is still non-interactive). So, both interaction and communication needs to be given to him from the premises. The surroundings are the first thing he sees. They offer orientation which is a form of communication, even if not much interactive at all. If the exhibition is in a museum the exhibits can offer new ideas in the form of knowledge. Surprisingly, though, the exhibits themselves are capable of giving more new ideas than e.g. information texts, no matter how thorough these might be. The reason for this is that the information text limits the comprehension often e.g. to the historical relevance of the object. When seeing the exhibit itself the viewer does not have any constraints, he might view the object in relevance with any science or art if he so chooses. Information text is slightly more interactive, though, because it forces the visitor to choose how he reads it: how thoroughly, how skeptically or how consideringly.

Reactive interaction is still quite static, even if slightly more interactive than e.g. reading the information texts. Still, simple reactions do not give easily too many new ideas, since the given reaction is often somehow expected. Since the exhibit should give some idea in advance about what one can wait by pressing a button it does not communicate much more than that. In this sense even narrative and user-language are more interactive than plain reaction. They both can make people to expect the unexpected. User-language can go deeper with its communication than narrative, because the user-language can focus on smaller details when narrative should just keep the main storyline going on throughout the exhibition.

Interactions with goals are maybe interactive, but they are not free with their actions or communication. Both of these are planned in advance and they work only in certain limits. This is incidentally also true with human guides who can help the visitor to learn more about the exhibits. They might give plenty of new ideas, since their knowledge should be enough for that purpose (that is why they are there), but depending on the person the interaction is not necessarily much higher than with other interactions containing goals. The guide's goal is to explain more about the exhibit and this happens in the limits of his or her understanding. Many guides learn the information by heart and might just cite it when needed. In this sense it is not free interaction, since the answer for certain keywords might always be the same. It is still very dynamic action, as always when real people are involved.

Constructivism is highly interactive since it gives the people the freedom to choose their preferred exhibits and form the narrative themselves. This might deepen the knowledge but it does not necessarily communicate new things much, since the visitor prefers things he already understands. Open-end interactions are quite interactive, but they also might fall short of communication since there is not necessarily any goal or clear reason for the interaction itself.

It is good to notice that there are no ultimate truths with this field, since both static and dynamic interactions and communications can be used in exhibitions. They are all needed, only their meaning and location should be considered when planning the exhibitions.

8 RESEARCH

To get a clearer idea about the subject in question I made two researches. The aim in the first one was to find out the prevailing ideas about astronomy in the public. The second one was made by observing the people when they were visiting an interactive exhibition to find out if there were any mannerisms or similarities in the visitor behaviour.

8.1 Results from interviews made in Mt John Observatory, Lake Tekapo, New Zealand in November 2012

During my visit in New Zealand, November 2012, I conducted a survey in the Astro Café of Mt John Observatory. The survey was done by interviewing the visitors in the observatory and the aim was to find out their general level of knowledge of astronomy. Altogether 36 people were interviewed during two days. The survey consisted of four different questions.

Mt John Observatory is located in Lake Tekapo, a small township by State Highway 8, South Island in New Zealand. Its location almost exactly in the middle on the route from Christchurch to Queenstown makes it a natural place to stop for tourists. During the years the observatory has become famous for its stunning sceneries, and e.g. the Lonely Planet guidebook mentions the Astro Café's spot on Mt John to be "quite possibly one of the best locations on the planet for a café" (Lonely Planet New Zealand 2008, 568). This is why Mt John attracts several tourists all year round and is thus a great place to get a mixture of interviewees from different cultures.

The interviewees were selected randomly and the nationalities varied from New Zealanders to Australians, Malaysians, Americans, Israelis, South Africans, Englishmen, Germans and Swiss. The language was mostly English, only with the Swiss and partly with the Germans the interview was conducted in German.

First question was "How many constellations are you able to name?" The meaning was to find out what people think would be their knowledge level about stars and if they were right away able to connect the word “constellation” with the groups of stars in the sky. The idea was not to be able to recognise the constellations from the sky (the survey was done during the day time), but to understand what is a constellation and what examples they can come up with. People also did not need to name the constellation aloud, they only needed to say how many they *think* they can name. Thus it is not probable that the people who gave the biggest numbers would really have been able to name as many constellations if asked, but it also was not the purpose of this question. Some couples preferred to answer together and this reduced the number of answers to 30 from all of the interviewees.

The answers varied from 0 to about 30 constellations, average being 6 constellations. (Figure 2.) Median value was 3. Approximately every fifth was able to connect the zodiac and thus the 12 horoscopes to be also proper constellations, which naturally raised the average number a lot. Most people (6) answered they would be able to name two constellations. Most often these two would have been the Plough (the Big Dipper) and Orion’s Belt, neither of them a proper constellation but just a part of one: the Great Bear and Orion respectively.

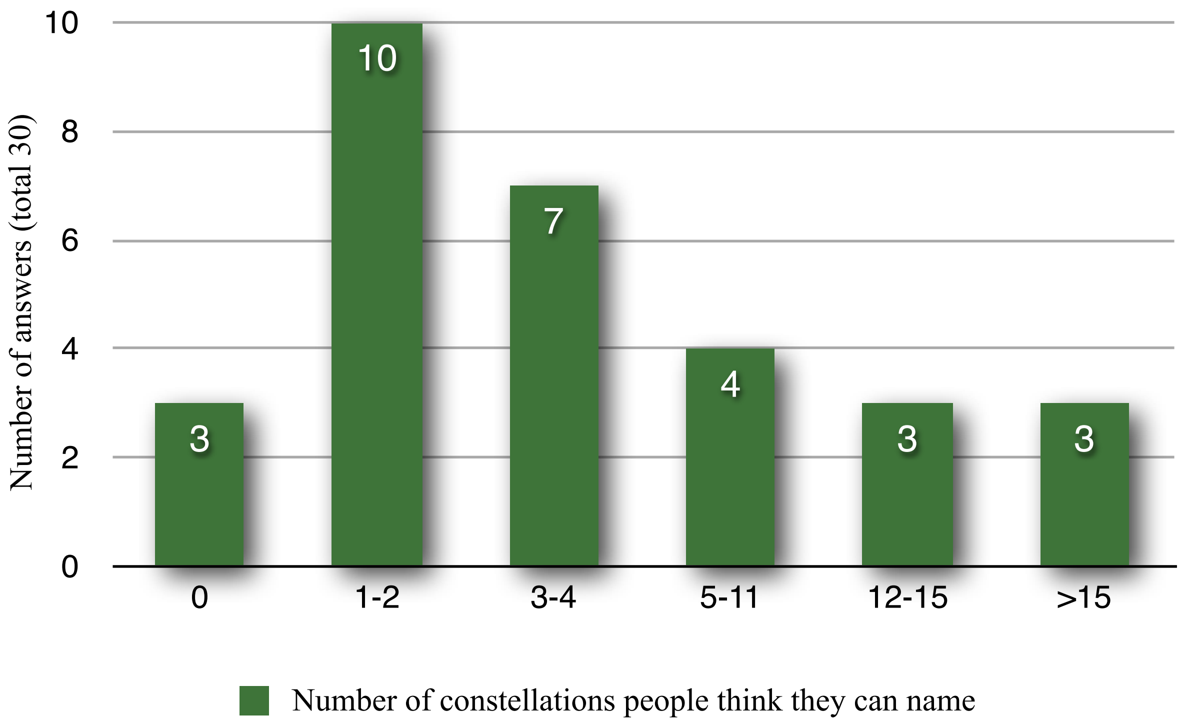


FIGURE 2. Answering statistics for the question “How many constellations are you able to name?”

Three people said right away that they would not be able to name any constellations. Partly this was because they did not have any clear idea about what a constellation was and partly because they did not know any. Many people hesitated answering in fear of showing their lack of knowledge, but with slight encouragement they did reply.

According to the results, the level of knowledge about the constellations is limited for most people to two or three constellations. Many people also said that they only know about these and would not be able to recognise them from the sky. This is good to remember when planning anything star chart related: the idea of the star formations is unfamiliar for most of the people and it might be difficult for them to connect the abstract idea of a constellation to any given form in the sky. One extra point was that many Australians and New Zealanders did not connect the Southern Cross with the constellations even if it is depicted in the flags of both of the countries.

The next question was about the interests of the interviewees towards astronomy. (Figure 3.) The question was “If you would want to learn more about astronomy, what would be the area you would prefer?” The alternatives were

> **History and Mythology** which also included astrology related materials,
> **Basic Information about the Universe** for those who would like to know more about how the universe works,
> **Amateur Astronomy** to find out what amateurs can see and do and how to get started,
> **Newest Science Discoveries** to keep the person in grip with the science and technology and
> **Something else** which the interviewee could name himself.

The reason for this question was to find out in which areas to focus on in possible presentations and guidings and in which proportions. Curiously, the newest science discoveries were the area most people would prefer, regardless of their previous knowledge about astronomy or science. This was closely followed by the basic information about the universe. Amateur astronomy was favoured by a few as well as history and mythology (mostly because of the astrology). No one stated to prefer something else, most likely because they had already made their mind while I recited the possibilities and because they did not feel like knowing many other alternatives.

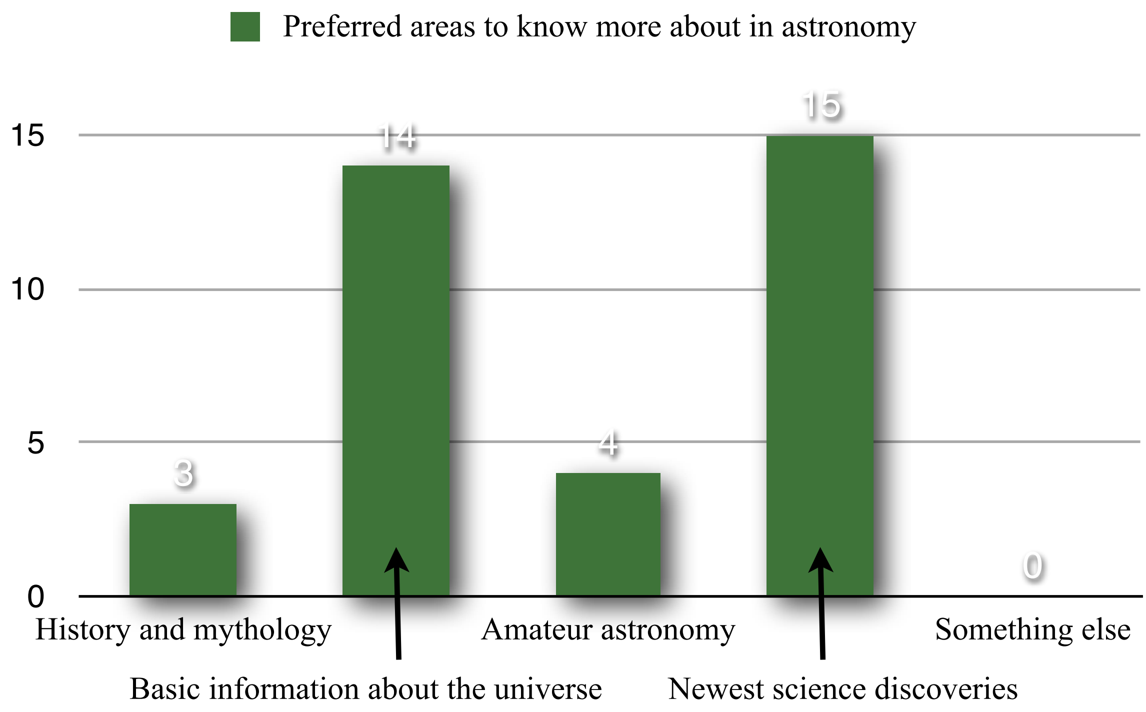


FIGURE 3. Answer statistics for the question about what part interests the interviewee most in astronomy.

This leads to the notion that in any given presentation the public will likely be happy if they are every now and then treated with well explained snippets about the latest discoveries in the field. (This is further encouraged by the research made in the UK about public attitudes to science in 2011, where 51% of the people in survey stated that they “think they hear and see too little or far too little information about science”, but only 32% think they are “not clever enough to understand science and technology” (Public Attitudes to Science 2011, 10). Especially in astronomy such pieces of information are frequently coming in and they can easily be welded into the core performance. These pieces are also a good way to explain the basic information about the universe, just to make sure the public will understand the meaning behind the new discoveries. When properly done, most people will go away happy after the presentation.

Third question was more open, even if I had quite clear expectations about what people would answer. To find out the degree of comprehension about astronomy can be – to certain level – checked very swiftly by asking simply “What is the biggest difference between a star and a planet?” The answer “I don’t know” means that astronomy does not play any part in the life of the interviewee, even if this does not necessarily mean he would not be interested about the subject if it was presented to him in an engaging way. The answer "planets are smaller" shows that the person is a novice considering astronomy. He has read or heard some fragmented information about the space and drawn his own conclusions about it. If the answer is "planets orbit the stars", this means the person has already gained decent knowledge about astronomy, but more in the form of details and not in the form of a big picture. When answering "the stars shine" the person indicates he understands some of the framework of the universe and at this level it often already affects his worldview by recognising that the Sun is also a star in the midst of billions of others. By saying "the stars create energy (through fusion reactions)" the person is aware of how our solar system and the whole universe work. This level is only reached when the person is really engaged and interested in the subject.

What is curious is that no answer is completely wrong. It just indicates how far the person's understanding reaches at this point. When he reaches the next level he normally will no more cite the previous answer, because he recognises the problematics and faults in them. Such questions are very handy while figuring out what level the presentator must choose to explain certain astronomy related things to the audience. People are eager to answer to this type of a question, because they normally have at least the novice level and will thus not feel they will give a wrong answer.

So, the third question was "How would you define the biggest difference between stars and the planets?" (Figure 4.) 33 people answered this question (three couples gave a unified answer). Two people admitted right away that they did not have any clue about any relevant differences. Three gave fragmented information like "planets are made of rock, stars are gas", "planets have water" and "stars are smaller". This shows that there is no broader understanding behind these answers. They are not entirely wrong, because there are cases where all these are true, but in modern science they are not the most obvious differences. If the person understood the context behind these cases they would give these answers only as special examples. This leads to the conclusion that these answers are fragmented information, read or seen somewhere but not fully understood or comprehended wrong. Without the basic understanding it is hard to remember the details correctly.

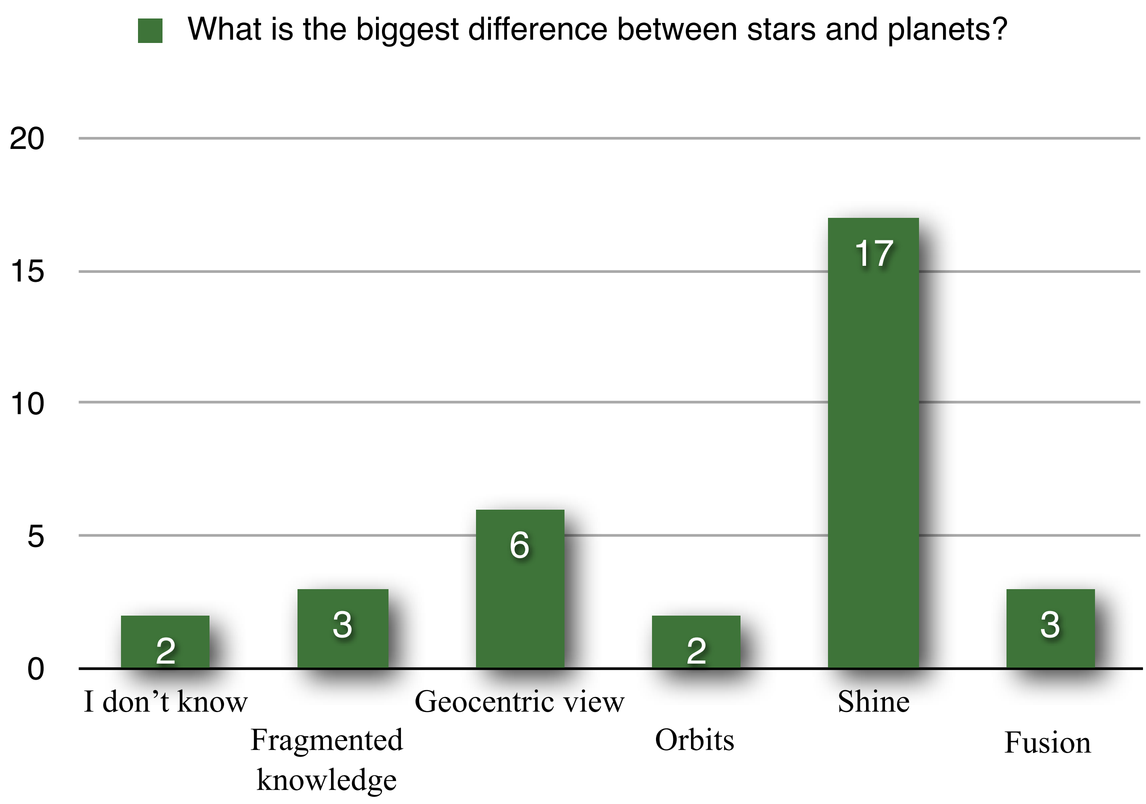


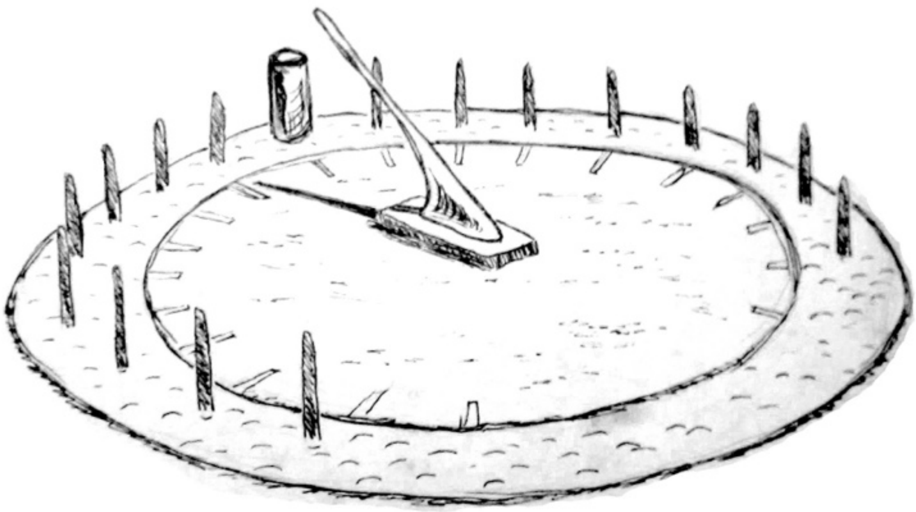
FIGURE 4. Answer statistics in understanding the difference between stars and planets.

Two people stated that "the planets are near, the stars are far" and four said "the planets don't twinkle and the stars do". Both of these answers indicate that the people think the heavenly bodies as they are when observed from the planet Earth, i.e. geocentric. Since all documentaries, schoolbooks and presentations normally show astronomical things in the context of space (i.e. as seen *in* the space), this approach inclines to the thought patterns where astronomy *as science* does not have a huge impact on the lives of the interviewees. This does not mean that they would not be interested, though, it is just another way of seeing things and inclines more to the observable, even amateur, astronomy.

Two people answered that "the planets orbit the stars", which does prove certain understanding about stellar systems. Seventeen could say that "the stars shine, the planets don't" which was the most popular answer. This is also the level which is normally considered general knowledge when talking about astronomy. Three people could tell that "the stars use fusion to shine" and this was the master of the answers.

If the "stars shine" and "stars use fusion to shine" answers are considered good and great answers respectively and "orbiting" an average one, than 2/3 of the interviewees gave answers that prove they have decent knowledge about the differences between stars and planets. This helps to create an image of the understanding in e.g. presentations. It is good to remember when telling about astronomical things that there is a vast number of people who do not have a coherent idea about things in question – in this case 1/3 would very likely find it hard to follow if the presentator would talk about details in our Solar System without first explaining very basics about it.

The last question was a picture question. I showed the interviewee a picture (Picture 9.) and asked them if they would recognise the thing if they saw it anywhere around Lake Tekapo. Then I asked them what one does with such a thing and if they would be able to use it.



PICTURE 9. The image showed for the interviewees. Pic: Ahlamo 2012

All 36 answered this question. Eight said that they did not know what it was or gave a wrong answer ("Stonehenge" was mentioned two times). Ten people recognised it to be a sundial, but they said they would not be able to use it to read the time without the guiding text. Eighteen people said they know it is a sundial and would be able to use it, too.

For the last, I asked them to read the time for me as it was depicted in the picture. I had deliberately left out the numbers from the picture, because there is a grave difference between sundials in the northern and southern hemispheres. In the northern half of the globe, the sun moves from left to right, when in the southern hemisphere it moves from right to left. So the shadow of the gnomon moves to opposite directions in the two hemispheres, clockwise in the north and anticlockwise in the south.

The most curious notion was that all the people who did try to tell the time from the picture (eighteen altogether) read it as they would have been in the northern hemisphere and said the time to be around 11am. This included all New Zealanders, Australians and South Africans who gave a try to tell the time. There was only one person (from Germany) who instantly said that telling the time depends in which hemisphere the sundial would be. And even he did not take in consideration that during the time I did the survey New Zealand was having its daylight saving time which adds another hour to the time – so instead of 1pm in the southern hemisphere the time would be 2pm.

The reason for this question was not that much if the people would be able to use a sundial but to see how certain they would be not to do a mistake when trying to decipher the time. (It indicates the probability which with they would omit reading the instructions even if they were presented.) The number of wrong or only partially right answers shows that there is a strong need to have instructions clearly on display with any such equipment to encourage the people to read them. People who gave an answer had very little doubt that they would not have answered correctly. I was surprised by the number of southern hemisphere people who were so brainwashed into the northern hemisphere thinking that they fell into the trap smiling.

8.2 Visit to Heureka – the Finnish Science Centre

I visited Heureka – the Finnish Science Centre in February 2013. The purpose of my visit was to observe the behaviour of the visitors and see if there were any patterns I could find. Another reason was to survey and value the exhibits and see if I could find out what works and what does not.

During my visit the science centre was in the middle of constructing new exhibitions and only the basic exhibitions (Heureka Classics, Science on a Sphere and the main exhibition area) were open. It was also not the time of any school or national holidays, so the number of visitors was rather limited. I did observe two school groups and a group for elderly people which helped me to compare behaviour in different age groups.

The exhibitions divided into *Heureka Classics*, which are stationary exhibits, mostly explaining different physical phenomena and *Science on a Sphere*, which is a big globe onto which different maps are reflected. There was also the main exhibition area, where there were three full exhibitions: *Intelligent Traffic*, which told about different traffic solutions mainly in the capital area, *About a Coin*, which explained the process of minting and *The Wind in the Bowels*, which was about the digestion. On top of these there were few fixed exhibits in the main area. I concentrated in the first four exhibitions only and did not interact with the rest.

I observed the visitors when they engaged with Heureka Classics since the exhibition hall was spacious and I could see many people from my observation point at the same time (picture 10). The exhibits are mostly the same size and it takes roughly the same time to engage with them. They are also interactive, so some action is always needed to reveal the idea behind the objects. This is why they serve as a good example about how people behave in interactive exhibitions.

When observing the visitors certain patterns soon became clear. The children in the school groups went around the premises in pairs or groups of three or four. Their use of the exhibits was random, and I got the feeling that they were having a competition about who finds the most interesting exhibit. This feeling was caused by the shouts "hey, this is cool" and "come here and check this out". Even if they moved from exhibit to exhibit as a group, they often tested the exhibit only once and during this time someone from the group already moved on to the next exhibit. They did not always go to the exhibit next to the previous one, but visited first the ones they thought might be more interesting. Adults were more eager to move around also by themselves, even if the most common way was still to go through the exhibition together with one or several people. They also normally visited the exhibits systematically in their order.

PICTURE 10. The Heureka Classics -exhibition hall. (Pic: Ahlamo 2013)

There was a clear difference between children (under 16 years old) and elderly (over 60 years old). (Note: the age of the visitors was speculated by me according to their outer appearance.) Children were very eager to try the exhibits without reading the informative text first. If there was a button, it was pressed. If there were several buttons, they were all pressed and moving parts were turned around. Especially boys about 12 years old often did not even look at the text but tried the exhibits and even moved on if there was boring or unclear reaction from the exhibit. Then again, elderly people mostly read the text fully through before paying attention to the exhibit itself. Sometimes they did not even try the function, but moved on after reading the instructions. It seemed to me it was more important for the elderly to know what is supposed to happen when using the exhibit than really getting engaged. I did not see the older generation to use many of the physically demanding exhibits, even if they were very popular among the younger ones, especially boys.

I measured the time people used to read the information texts from 20 persons when they first approached the exhibit. From these 20 people 7 did not read the text at all, all of them children. Two spent more than 20 seconds with the instructions. Average time spent reading the instructions was 8 seconds. This means there were very few people who read the whole text. Since the text presentation of Heureka Classics always starts with clear instructions about what one needs to do, and is then followed by more detailed information what conclusions can be drawn from the phenomenon the exhibit represents, I got the feeling that most people only read the part where it is said how the exhibit is supposed to be used.

It seemed to me that the most common way to approach any given exhibit was to read the instructions. If there was movement involved with the exhibit, people did try to figure out first what was happening before starting to read the text. Some people also tested the exhibit shortly before starting to read the text. Most people, after reading the text for a while, tested the exhibit and then turned back to read more. This was likely because of the way of the instructions: after people had read what they are supposed to do they tried it out and then read on to see what it all meant.

People seemed to be drawn to the exhibits where there was movement going on. Especially simple looking things with clear idea about what needs to be done were very popular. There were few exhibits that needed two or more users, but most of them were possible to use by just one person. Tim Caulton points out in his book that the visitors will sooner or later do the unthinkable (Caulton 1998, 29). It was slightly amusing to notice that this really was the case when one boy started to pick things from different exhibits and mix them up – which naturally led to small malfunctions and challenging situations.

Next I moved to the exhibition area for “Intelligent Traffic”. According to Heureka: “The exhibition is about information and communication technology and how they are being used for the benefit of traffic safety, the smooth flow of traffic, efficient and environmentally friendly traffic. The exhibition has been produced in co-operation with ITS-Finland and its member communities."

Personally, I found this exhibition the weakest of the ones Heureka had during my visit. The exhibits were not terribly interactive and they had some clear flaws if considering user experience or even their meaning. During my visit the most used exhibit from this display was the driving simulator (picture 11). It was well done in the sense that there was enough room for several people to see what the user was doing and the feeling was realistic (because the animation did not clog too often). It was also clearly the highlight of the exhibition, but I did wonder what the target group was. During my visit I saw only children engaging with it and I did not see any point engaging with the exhibit myself, because even if I do not drive very often I already have a clear idea about what it is like.

PICTURE 11. The driving simulator (Pic: Ahlamo 2013)

There were some poorly created exhibits around, too. One console had three monitors displaying the flight traffic in the United States, the bus and tram traffic in Helsinki and the marine traffic in the Gulf of Finland. The user could explore the flight and marine traffics with a mouse, finding out the names of the vessels or the flight numbers. These services can be freely used on the Internet (e.g. www.flightradar24.com and www.aprs.fi), so they are not exceptionally peculiar. The bus and tram traffic monitor offered the user five buttons but no explanation what the buttons meant (picture 12). In the info text nearby it did say the user can push the buttons to see the buses and trams in real time in different places, but I could not find any information about what these places were. Without reading the text it would have been hard to realise that the buttons represented locations, since the other monitors around had the focus on the vessels and airplanes. It was slightly confusing to press a button with a number and then see a tram or a bus with another number to drive past.

PICTURE 12. The monitors for air, bus and tram and marine traffic. (Pic: Ahlamo 2013)

The idea of the exhibition was good, but the way it was produced felt slightly nonchalant. There was no clear theme other than traffic, but I would have liked to see some connections between the exhibits. I also felt that often the message behind the displays stayed hidden because of the tricky user experience or malfunctioning devices. It would have been better if there were more connections or common themes between the exhibits in the basic level. Now they felt fragmented and somehow superficially done.

When evaluating the surroundings, I noticed many things done by the text book. Heureka uses clear colour codes to point out the limits of their exhibitions (picture 13). The overall feeling of the place is spacious, but also somewhat disconnected in some parts. There are several single exhibits that do not really go together and that is why their real meaning might not come out as well as it could. (These include e.g. the sea state in the northern Baltic Sea, building an igloo exhibit for young children and the platform which with the user can feel how an earthquake feels like – all of them right next to each other.)

PICTURE 13. Heureka interior. (Pic: Ahlamo 2013)

There seems to be enough space around many exhibits for the people to gather and many things can also be explored together. It might be good to have more exhibits were communication skills as well as teamwork would be requested to get results. This would add more to the social capital that is often greatly valued as a great consequence of a visit to a science centre. (European Network of Science Centers... 2008, 14.)

The Heureka staff was very eager to help people with the exhibits. They were friendly and thorough and happy to engage with the exhibits themselves. Naturally there are also differences between the persons, I talked with one of the guides and she seemed just citing her knowledge about the exhibition, without taking much part in the conversation I tried to engage. Other guides did seem to raise positive ideas in the visitors and especially the younger people very likely got more out of the exhibits with a little help, especially since they so often omitted reading the texts.

All in all, the visit was very interesting and I was able to see in action many things I have read about while doing the research for the theory part of my thesis. It was good to see and evaluate the exhibits and thus get realistic examples of the theory. Observing the public was also very useful and gave me new ideas.

It seems to me that what Bradburne (1989) talks about the next generation of science centres is definitely relevant. Heureka is one of the very few science centres in Finland but somehow I feel its ways have not evolved greatly since it was established in 1989. (I visited Heureka soon after it was first opened and several times afterwards during the years.) Naturally there are budget, theme and style considerations, but according to what I remember from my first visits I cannot say that much would have changed with the exhibitions. They still seem to be rather fragmented and simple and never quite reach the highest possible levels of interactivity.

Nevertheless, my visit in Heureka reminded me how tricky it is to plan good interactions. Especially the Intelligent Traffic exhibition revealed how vital it is that there is a complete idea about what the exhibition and the exhibits should be about before even starting to plan them. This idea should also always stay in the mind of the designer when doing their work. Making errors is not shameful. Not correcting them is.

9 CONCEPTS FOR AN INTERACTIVE ASTRONOMY EXHIBITION

This part of my thesis presents a few ideas for concepts of a hypothetical astronomy / physics exhibition. The concepts are by no means meant to be final, the emphasis is in the ideas about how to make complex physical phenomena understandable for the public while being interesting. With some examples I have conducted small user surveys to find out how well the tasks are understood. The concepts are targeted to adults as well as children who are older than 12 years.

9.1 Primary exhibits

These concepts I have developed further than just the basic ideas. The visuals are meant to give an overall feeling about the exhibit in question, not to present the final design. I have been trying to accommodate several different interactive methods to keep it innovative.

9.11 The Electromagnetic Spectrum

Goal: To get the user acquainted with the electromagnetic spectrum and to point out that light is just one type of radiation in this continuum. To help people to realise that many everyday gadgets are applications of different frequencies and wavelengths of the electromagnetic radiation.
Equipment: Wall-size representation of the electromagnetic spectrum with buttons, sliders, control board, etc.
Interaction levels: Reactive, hands-on

Synopsis:
One of the key presentations in physics is the electromagnetic spectrum. It depicts the electromagnetic radiation visually as a continuous bar where different wavelengths equal different frequencies and energy dividing the radiation in the areas of gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves and radio waves. There is a

lot of information packed in such an image and people who do not have much background in physics can find it terribly technical and uninteresting.

To get people interested in the electromagnetic spectrum it must be presented in an interesting way. The first glance at the spectrum can feel stupefying, since there is so much information and difficult terms. That is why the info needs to be broken down into smaller pieces. Then people can investigate them one by one and slowly build the big picture. This is done by dividing the spectrum and its applications e.g. to the following parts.

Different parts of the electromagnetic spectrum (picture 14):

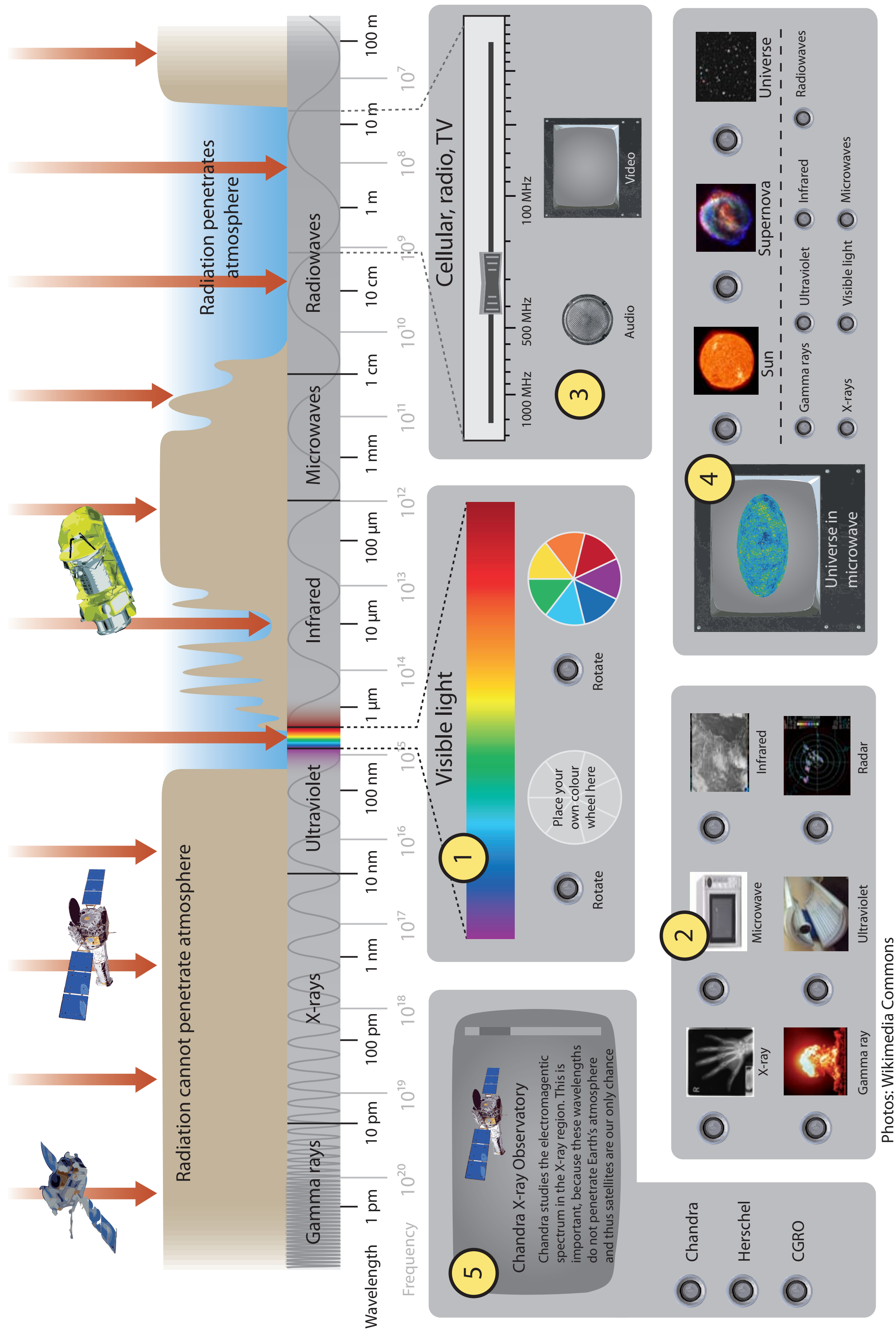
1) *Visible light*

Light is the most familiar part of the electromagnetic spectrum for us. It consists of the colours we see and it is difficult for us to think there would be anything else than that. Still, visible light is a very narrow band in the whole spectrum, it covers the wavelengths 380-740 nm, from the deepest violet to the darkest red. This is the area we are able to see, mostly because the Sun radiates most of its energy in these wavelengths. There are some insects and animals, though, which are able to see also some infrared and ultraviolet wavelengths, too.

When we talk about light we often mean the white sensation of something bright, like the sunlight on a bright day. White light itself is not really “white”, it is a collection of the colours that mix together. In this part the visitor can try this out by **rotating the given colour wheel** with fast speed. The colours seem to blend into white as long as the wheel is rotating fast enough. The visitor can also paint his own wheel, attach it to the axel and rotate this wheel similarly to see what happens.

2) *Parts of the spectrum*

We use every day several different applications based on the electromagnetic spectrum. It also hides the answers to many questions like “Why are X-rays so dangerous?”, “Why is it possible to see things in the dark with an infrared camera?”, “Why are the satellite dishes so big?” and “Why do they say it is dangerous to sunbathe too much?”.



PICTURE 14. Early wireframing and concept art for the Electromagnetic Spectrum (Pic: Ahlamo 2013)

The shorter the wavelength the more energetic the radiation is. (It is good to notice that electromagnetic radiation is not the same as particle radiation, even if they are both called “radiation”.) One of the characteristics of electromagnetic radiation is that when there is an object of certain size the radiation which has longer wavelength than the object passes through it without any effect, but the radiation with shorter wavelength than the size of the object will impact with it. Since the shortest wavelengths have considerable energy they can do substantial damage while making contact.

In this part the visitors can explore which parts of the spectrum different applications use. E.g. when the sunbed button is pressed, the part for those wavelengths will light up in the spectrum. It is possible to add several other applications to this section, as well as the objects that equal the sizes of the wavelengths. A good example would be a DNA sequence (ca. 2.5 nm) which equals the wavelength of X-rays – clear indication why constant exposure to X-rays as well as short amounts of gamma rays are very dangerous: they both will destroy the structure of the DNA, because their wavelengths are so short.

3) *Radio, TV and cellular frequencies*

One of the most common and useful ways to use electromagnetic radiation is to transmit information through long distances. Radio waves with their long wavelengths are good for this, because they penetrate even the big objects easily. In this part the visitor can investigate, on which frequencies different information is transmitted.

By moving the slider sideways between different frequencies it is possible to listen to (staged) mobile phone conversations and radio channels. In the right frequency also the provided television will show image. This helps the user to understand that tuning the radio or television is actually just observing different parts of the whole electromagnetic spectrum.

4) *Objects in different wavelengths*

By observing different astronomical objects in different wavelengths it is possible to find out much more about them. In this section the user can see some objects (e.g. the Sun, a supernova remnant and the universe) in images taken in different wavelengths.

By selecting the object and pressing the button for the preferred wavelength the image appears. There can also be some information about that particular image as well as what it tells us about the object itself.

5) *Satellites*

One of the main reason there are space observatories – the satellites that observe the universe – is that very little of the electromagnetic radiation coming from the space penetrates Earth's atmosphere. This is naturally very good for the life on Earth, since e.g. gamma ray and X-ray radiation would be very hostile for us. Still, this means that to observe the space in these wavelengths we need satellites. In this part the user can explore what kind of satellites there are up there, find out how they operate and which scientific discoveries they have done. By selecting the satellite the user can read about its details and see which part of the electromagnetic spectrum it investigates.

9.12 Charge the atoms

Goal: To explain the basic idea behind charged atoms and their relevance in the spectrum of light

Equipment: Big touchscreen and soft white balls

Interaction levels: Interactive, hands-on

Synopsis:

This is a game where the player needs to throw a soft ball representing a photon to a touch screen to charge the individual atoms in the constantly passing flow. The harder the player throws, the more energy the electrons gain and thus bluer (spectrumwise) the atoms seem to become. The charge is soon released and the atom emits colour and adds points for the player.

The equipment naturally needs to be able to track the strength which with the ball hits the screen. The screen should also be installed inside some kind of a structure, where the thrown balls will scroll back to the thrower to be reused. The balls should be gray or white to avoid confusions with the colours from the charges. (Picture 15.)

Incentive and instructions:

Charge the atoms! How big charges are you able to create? Throw the photons and try to hit the atoms passing by. If you manage to get a hit, the atoms will get charged by the photon – the electrons will jump to a higher energy level and you can see an absorption line in the spectrum. Soon the charge will be released and you will see how many points you got.

The harder you throw the more energy the atoms will get. Notice that you can get more points also if you throw very slowly. The most points you will get when you hit the ultraviolet (very hard hit) and the infrared (very slow hit) areas. The game ends if you reach 1000 points.

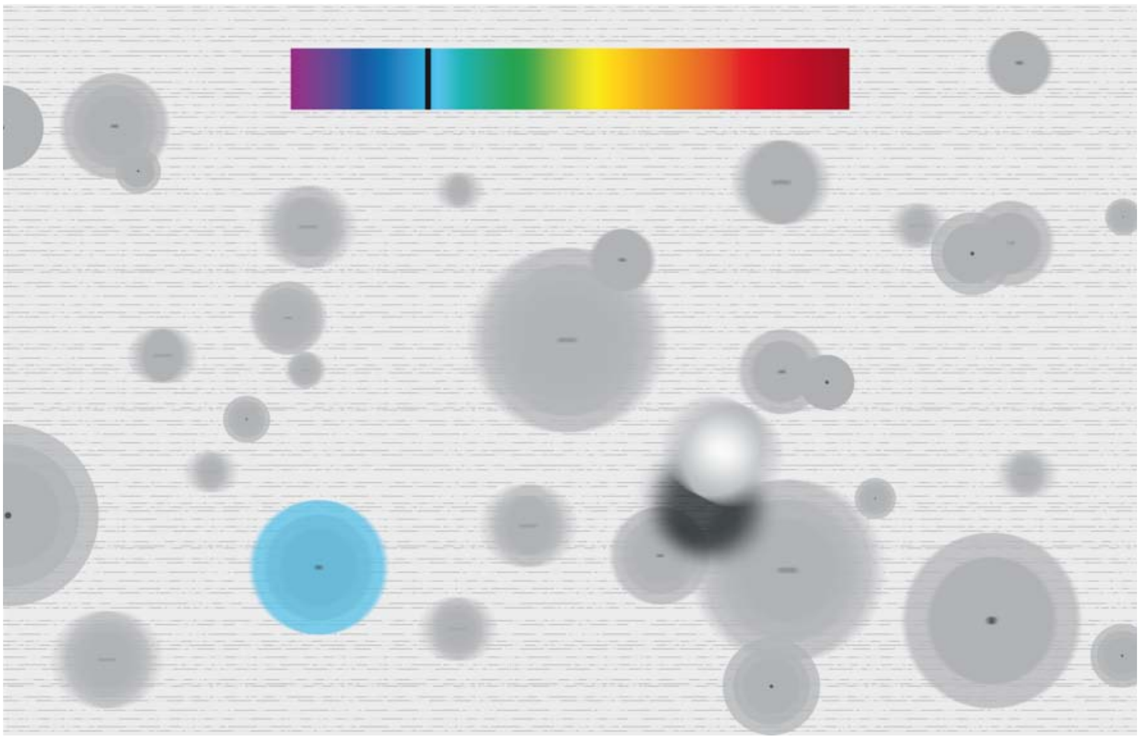
Points:

Yellow, orange and green: 75 points

Blue and red: 100 points

Violet and darkest red: 150 points

Ultraviolet and infrared: 250 points



PICTURE 15. Concept art for the “Charge the atoms” game. (Pic: Ahlamo 2013)

9.13 Spectrum of Light

Goal: To understand some of the fundamentals of spectroscopy

Equipment: Touchscreen, info texts with additional information for each level

Interaction levels: Interactive, minds-on

This is a game where the player needs to investigate the given spectrum to find out which elements it conceals. There are three levels:

Level 1: Find the elements from the spectrum

Level 2: Work out the abundances of the elements in the object

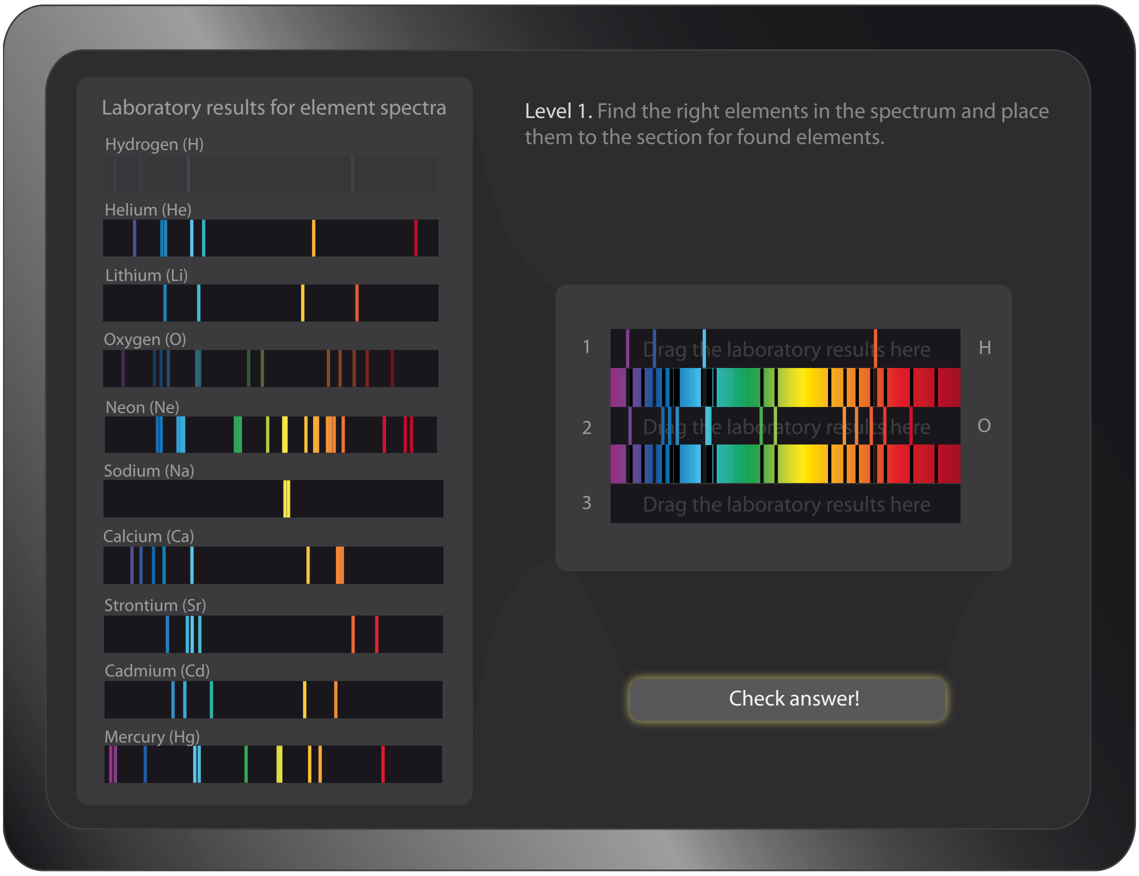
Level 3: Figure out whether the object is coming closer or moving away from us

Incentive:

Can you find the message in light? Light has a lot to tell. White light is not really white but a mixture of different colours together. Astronomers collect the light from the stars and other celestial objects and use prisms to refract that light into a colourful rainbow, a "spectrum". This spectrum tells us many details about the object where it originated, e.g. a star or a nebula.

Information on the screen:

When starting a level, it is best to show with short animations what needs to be done. Verbal explanation would be lengthy and frustrating. The idea, though, is to try to find out what the object is made of by tracking the chemical elements in its spectrum. (Picture 16) The laboratory results of elements are dragged next to the spectrum to be investigated. If the colourful lines of a particular element match with the black lines of the spectrum, this element is present in the object. (The dark lines need to be perfectly equivalent to the colourful lines to make a match.) Note that there are several elements represented in each spectrum, so each black line has to get its equal to get the level passed. When the choices have been made pressing "Check answer!" button will show if the answer was correct. If yes, the player will move to the next level. If not, the screen shows which one is wrong and gives the player the chance for correction.



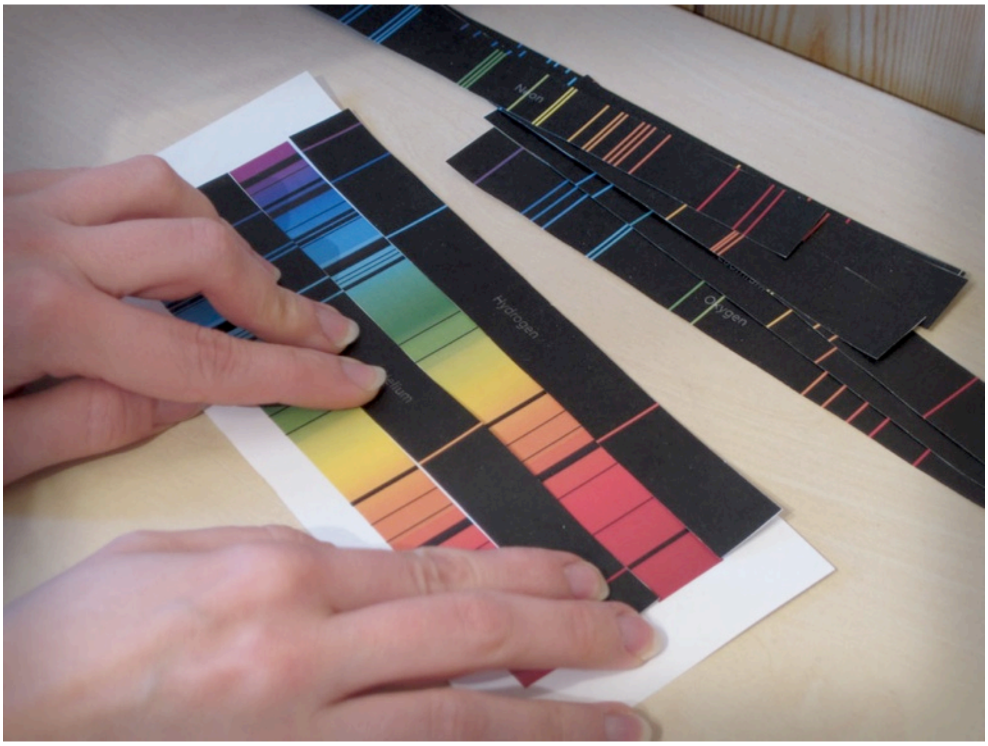
PICTURE 16. Early concept art for "Spectrum of Light" screens. (Pic: Ahlamo 2013)

Level 1: The task is to find the elements in the spectrum by comparing the laboratory results with the spectrum itself and deciding if the element is present.

Additional information: "With the right equipment you can see dark lines in the spectrum of light coming from the stars. These lines (called "Fraunhofer lines") are fingerprints of different chemical elements of the celestial object. In laboratories the scientists have found out which lines are characteristics to which element. By investigating these dark absorption lines and similar bright emission lines in the spectrum we can find out what the star, nebula or galaxy is made of."

Level 2: The task is to find the elements similarly in the same way as in the level 1, but this time the different lines are in different widths, representing the abundances of the elements in the object. The player needs to find the elements and place them into right order, the most abundant element first. (Picture 17.)

Additional information: "The strength of the line indicates the abundance of that element. Darker lines mean bigger quantities of that particular element in the object. This is very useful when we try to make out the exact mixture what e.g. the stars are made of. By knowing the quantities of the different elements inside stars we can calculate how long they are able to burn."



PICTURE 17. The idea of the game is to find the match for the coloured and the black lines. Here the lines of hydrogen (top black bar) have been found, they are the widest lines in this level indicating the high abundance of this element in the spectrum. (Pic: Ahlamo 2013)

Level 3: In this level the player must find the elements and place them into right order while observing if there is blueshift or redshift present, thus figuring out if the object is coming closer or moving away from us.

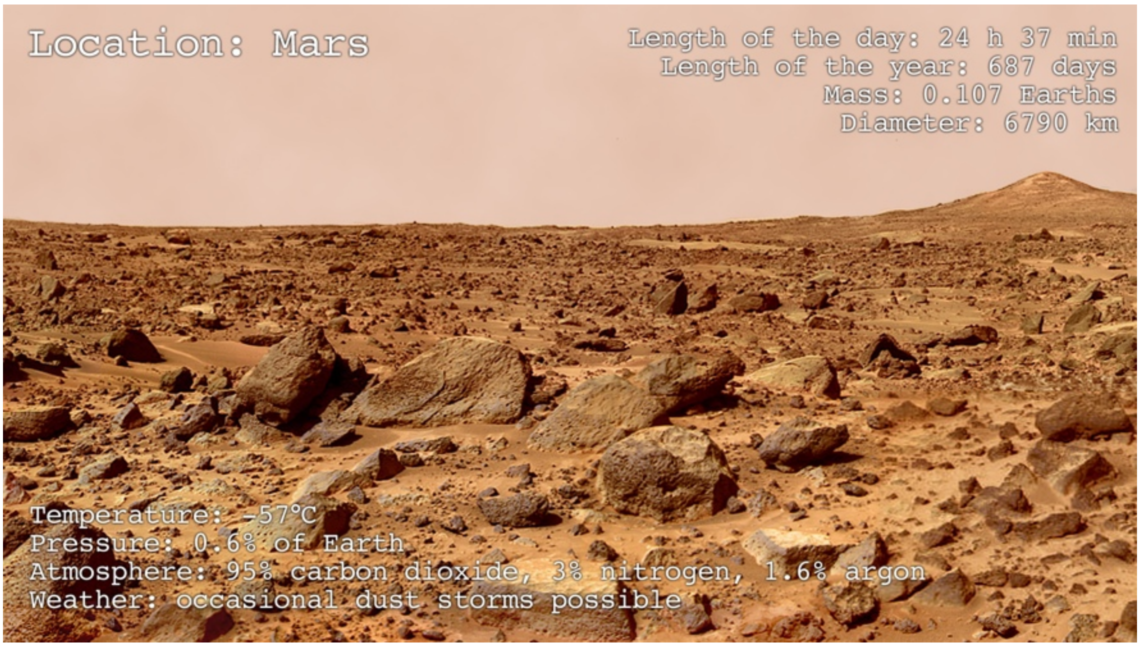
Additional information: "The movement of a sound emitting object causes the sound to shift towards lower or higher pitch as the movement either expands or compresses the wave pattern of the sound. This phenomenon is called Doppler effect and is commonly experienced when listening to a fire truck passing by. The same effect also happens with light. In a spectrum we can see the effect when the dark lines have shifted from where they should be when compared to laboratory results. The movement towards us shifts lines towards the blue end of the spectrum ("blueshift") and when objects move away from us the light shifts towards the red end ("redshift"). Since our universe is expanding, distant objects have very distinct redshifts. The further the objects are, the faster they move away from us and the more the lines shift toward the red end of the spectrum."

When the player has finished all the tasks the programme will show once more the assembled results from each level.

9.14 Planet Simulator

Goal: To give people an idea about alien worlds in our own solar system
Equipment: Screens with movable simulations from different planets and a control board
Interaction levels: Open-end interactive, hands-on / hearts-on

Synopsis:
How does the scenery look like on the other planets in our solar system? How big does the Sun appear in the sky in Mercury or Jupiter? We know that Earth is just one planet among many others in our Solar System, but we rarely get a chance to really explore and wonder how the other planets are like excluding the pictures we see in school



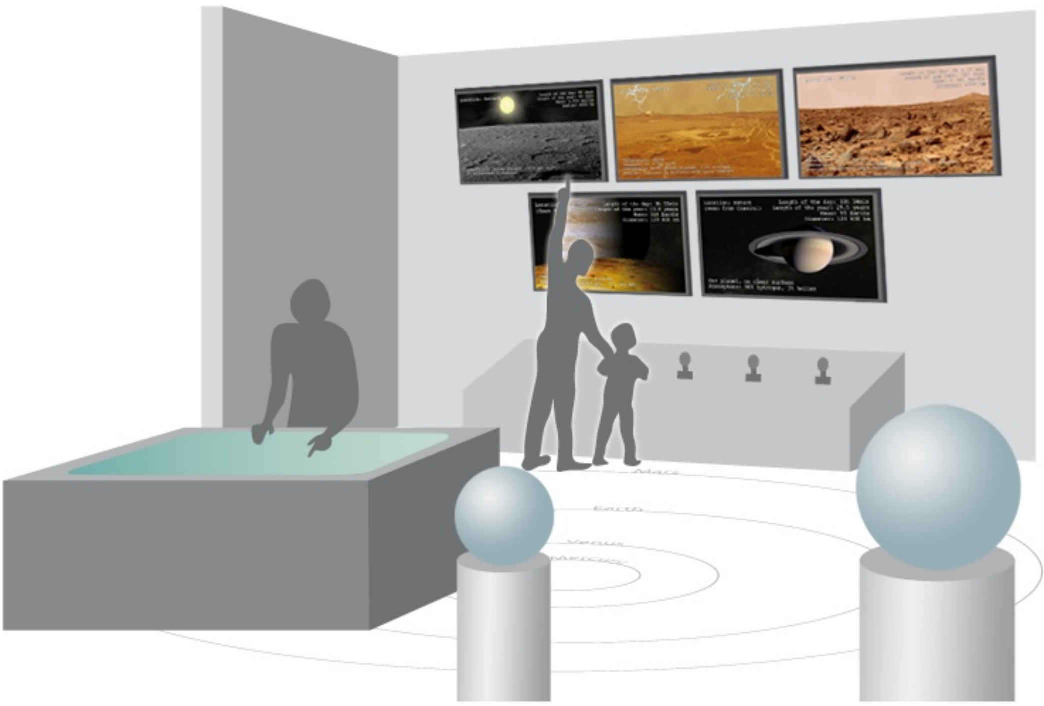
PICTURE 18. Concept art for "Planet Simulator" on Mars. (Pic: Ahlamo 2013, Mars scene from NASA)

books. This exhibit gives the user the chance to imagine visiting the other worlds, experience their sceneries and learn about their characteristics. The exhibit consists of big screens which also work as an incentive to approach the area which focuses on the Solar System and planet Earth.

Characteristics:

Each screen shows a simulated scene from each planet (picture 18). The simulation is movable around that object, the user can explore the ground as well as move to the space in the vicinity of the planet. There is a lot of information presented about the characteristics of that particular place. It is also possible to install a scale which measures the mass of the user and shows how much he would weigh in each world. The user can also visit e.g. different moons of Jupiter, admire the gas giant from various distances or dive into its clouds. The information on the screen changes accordingly.

The simulation can include e.g. dust storms on Mars, lightning on Venus and volcanic eruptions on Io. It should also be possible to select the speed of time so that certain details would be able to come out. (E.g. the pattern the Sun does in the sky of Mercury –



PICTURE 19. Preliminary concept art for the Solar System section of the exhibition (Pic: Ahlamo 2013, space pictures by NASA)

the day of the planet is longer than its year and thus the Sun draws a huge loop in the sky without setting when expected.)

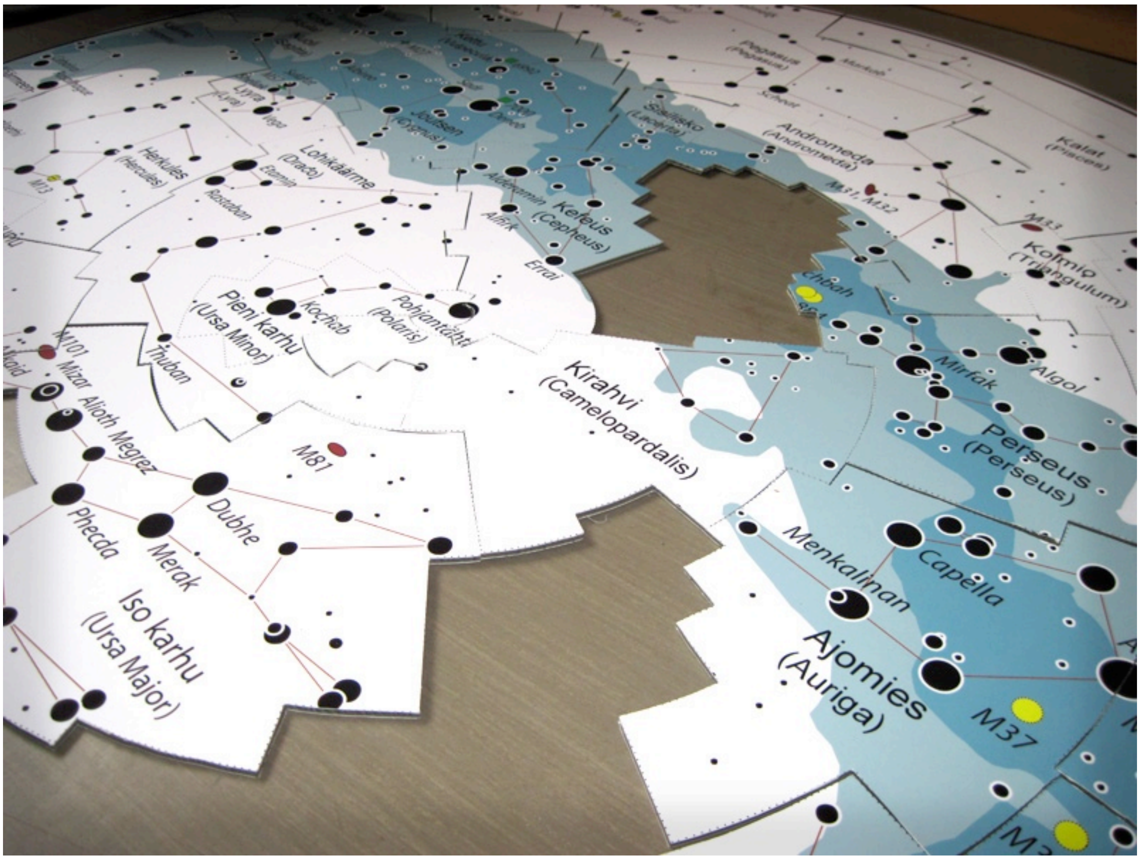
It would be possible to do just one big screen for the simulator, but by dividing it into diverse scenes several users can operate the system at the same time and compare their findings with each other. (Picture 19.)

9.15 Constellation Floor Puzzle

Goal: To get the users familiar with the arrangement of the northern hemisphere constellations
Equipment: Floor puzzle forming the northern hemisphere constellations
Interaction levels: Interactive, minds-on

Synopsis:
When we look up to the sky we see the constellations. Many people do not recognise too many of them or realise that for astronomers the constellations are not only the shapes we see in the sky but whole areas and segments of it. By putting this puzzle together it gives the user an idea which constellations go together and how they are distributed in the northern sky. It is naturally possible to do a southern hemisphere version of the puzzle as well.

The puzzle (picture 20) was made for an amateur astronomy event in Finland and it proved very popular among the users. It was not as easy to put together as many first thought and provided surprising challenge as well as leisure for its users. This could be even enhanced if a southern hemisphere version was available at the same time. Since both have a round shape, the similarity of the pieces would offer an extra challenge.



PICTURE 20. Constellation Floor Puzzle, detail. (Pic: Ahlamo 2011)

9.16 Speed of Light

Goal: To get people to comprehend the distances in space

Equipment: Indicators that show how far a light beam has travelled

Interaction levels: Reactive, hands-on

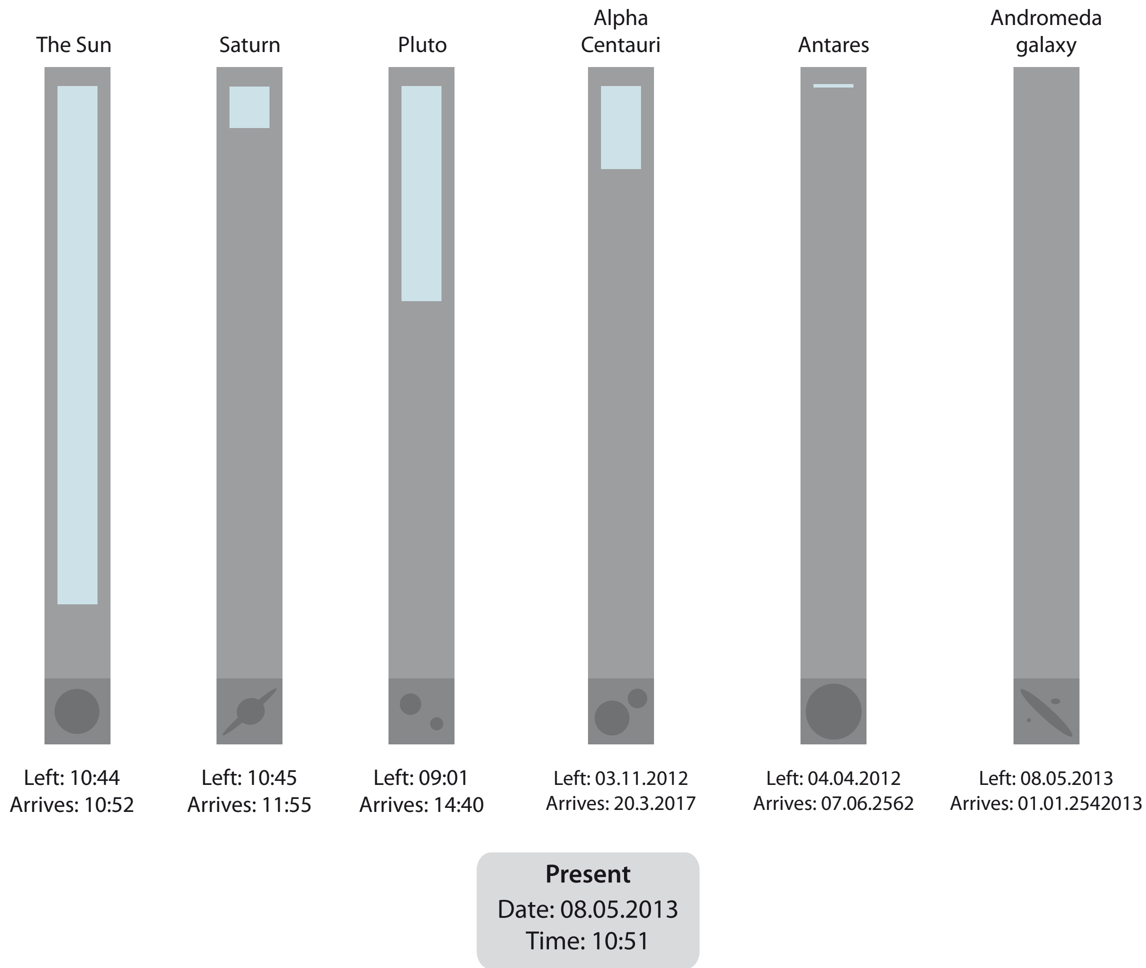
Synopsis:

It is pretty much impossible to understand the distances in space. We talk a lot about light years, but its true meaning often escapes the listener. The speed of light is the fastest known speed, ca. 300 000 km/s. Still it takes years before light arrives to our eyes from the distant objects.

With this exhibit we follow single beams of light when they travel across the space. The user can “launch” a light beam and the exhibit shows how long it will take for it to reach us. Since all objects outside our solar system are extremely far, the screen shows the date when the beam was launched. (Picture 21.) When the light finally reaches the bottom (the Earth) it will light a box showing a picture of the object. There could also be a part of the exhibit that shows how fast the light truly travels by e.g. showing that in one second a beam of light crosses a distance that is a bit over 7 times the length of the Earth's equator (i.e. circumference of the Earth).

Incentive:

How old is the light we see? Check how long will it take from light to reach our eyes from the distant stars.



PICTURE 21. Wireframing model for Speed of Light (Pic: Ahlamo 2013)

Possible objects and their distances:

Solar system (Note: we see the planets, etc. in our solar system because they reflect the sunlight. So, the beam of light travels back and forth between the Sun, the object and us before we can see it. The distance from Earth to other planets varies depending on their position in their orbit around the Sun. When using this exhibit, the current distance should be calculated by a computer programme to get the right travelling time for light.)

The Sun: 8,317 light minutes
Saturn: 71,4 – 88 light minutes
Pluto: 318,2 – 334,9 light minutes

Deep space:
Alpha Centauri: 4,4 light years
Vega: 25 light years
Antares: 550 light years
Andromeda galaxy: 2,5 million light years

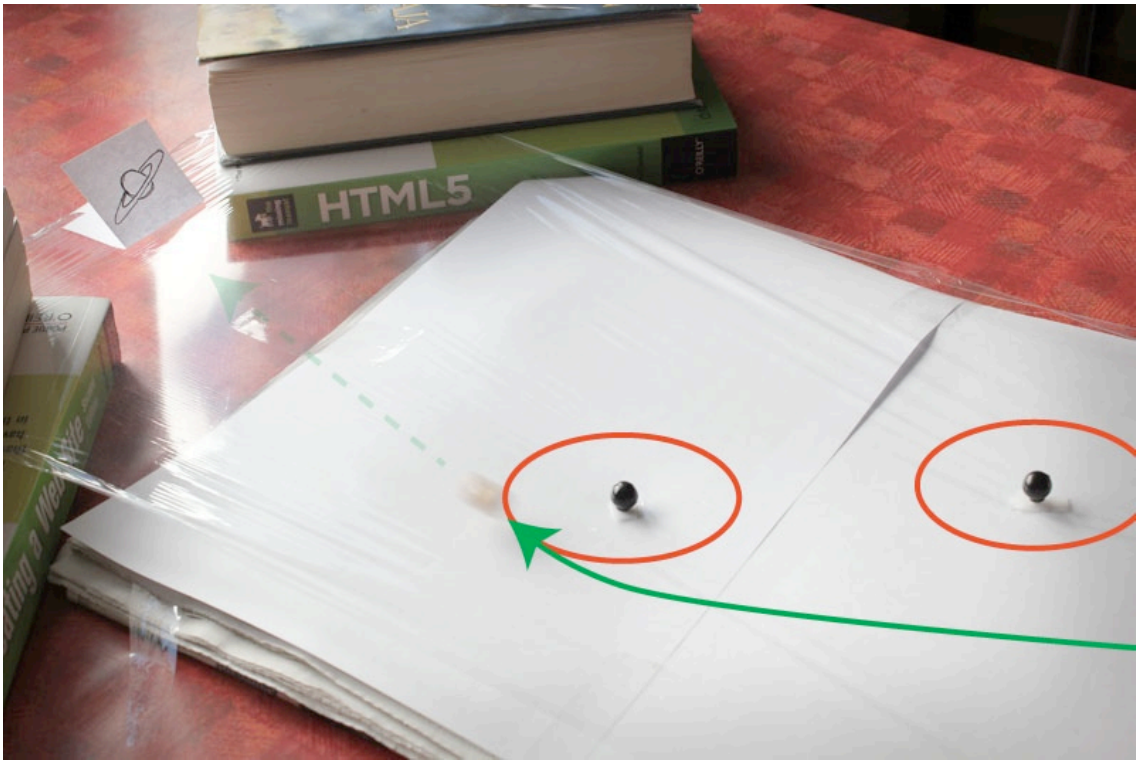
9.17 Solar System Pinball

Goal: To make the user familiar with the slingshot effect and how tricky it is to aim space probes
Equipment: Pinball-style game where the user needs to use the dents on the board to get the ball rolling to its target, the planet Saturn
Interaction levels: Interactive, hands-on / minds-on

Synopsis:
When sending space probes to investigate planets in our solar system we normally use the gravity fields of the other planets to give the probes more speed and the right trajectory to reach the target. With this pinball-like game the user can try it for himself. In the game it is not possible to get the ball shot directly to Saturn, so the player needs to use the dents in the gravity field on the board. By aiming accurately, the ball should slingshot itself further and finally reach its goal. Note: this is much harder than it sounds like. (Picture 22.)

It would be a good idea to limit the shooting event so that the ball cannot get too much speed. Then the attempts to shoot the ball directly into Saturn would fail when the ball would be disturbed by the gravity fields. The idea is also to get the ball arriving into its target smoothly, so that there is the chance for the probe to reach orbit around the planet. (Too fast a shooting would result in the probe flying past the target.) The orbit does not need to be shown, though, it is enough if the game shows that the target was reached (e.g. when the ball falls into a hole depicting the orbit of Saturn.)

This would definitely be a good idea to produce as a concrete exhibit instead of a computer programme. It would give the users an idea of something real and effective instead of an invisible theoretical force. It would also depict gravity in the same way it is often depicted in Einstein's theory of relativity.



PICTURE 22. Testing the Solar System Pinball idea with a crude DIY model. The push pins force the tight plastic wrap downwards creating gravity wells (red rings). The trajectory of the ball (green) turns in effect and is shot towards Saturn. (Pic: Ahlamo 2013)

9.2 Secondary exhibits

These ideas for exhibits still need some more investigation and work to make them usable. Here the idea is to present just the basic idea which then can be produced further.

9.21 Create yourself a planet

Goal: Getting people to think what is needed for a habitable planet
Equipment: Interactive screen
Interaction levels: Interactive / open-end interactive, minds-on

Synopsis:
In our everyday lives we rarely tend to think how special the planet we live on is. There is a lot of talk about climate change, but many people do not consider it believable or think that it would affect them much. Still, planet Earth is so far the only place in the universe that we know to sustain life. With this exhibit the aim is to explain how minor things truly can result in grave changes.

There are dozens of important factors when determining what makes a planet habitable for humans, and the scientists are not sure which ones are vital for life. Many details are under debate and we only have planet Earth as a role model. This is why this exhibit cannot be taken as the ultimate truth but more like a pointer towards how special our Earth really is.

Programme computing for a habitable planet:
The user performs a list of selections that the programme compares with the given qualifications. Since many of the selections are inputted with the use of sliders, the programme adds a certain random factor into each completed selection. The more unlikely and unpredictable the selection is the bigger the random factor. In the end the programme checks the total random factor and if it exceeds a certain level the created planet will not be habitable.

Incentive:

Create yourself a planet! Use the buttons and sliders to select characteristics for your planet-to-be. See if you can create a habitable planet for the human race to live on.

Characteristics to be selected:

These characteristics could include the following.

- *The location in the spiral galaxy.* Preferable location would be somewhere between the central bulge and the outer edges. A location too close to the centre would expose the planet to excessive radiation from the nearby stars and supernovas (star density is higher in the centre) whereas the locations in the outer edges would not necessarily provide enough heavier elements to build complex planets.
- *The distance from the star.* The hotter the star is the faster and more violently it burns its fuel and dies. Cooler and fainter stars are preferable for habitable planet formation because they normally have steadier and longer lifespans. The preferable distance would be in the “goldilocks zone”, it is the area in a stellar system where water can appear in liquid form.
- *The mass of the planet.* Too massive a planet could result in the collapse of a possible atmosphere, too light would leak it into space because gravity could not keep hold on to it. In this exhibit the limits for a suitable mass could be e.g. 0.4 - 1.8 Earth masses.
- *Plate tectonics.* Plate tectonics seem to be very important for living planets. On Earth, it keeps up the circulation in the atmosphere as well as the greenhouse effect. The same forces that create plate tectonics also cause magnetic fields which protect the planet from the excess radiation of the nearby star. Lack of such a field creates a huge pressure on the atmosphere and the solar wind can eventually bombard it to space.
- *Moon.* For a planet to have a stable axis it needs to have a decent size moon. Too small a moon will not be massive enough to affect the axis of the planet, too large could affect it too much. In this exhibit the lack of a moon might not be too bad, because even if there would not be life of its own on the planet it might be suitable for terraforming. (The idea was to build a habitable planet, not one which already maintains life.)

There can be as many these kinds of choices as preferred. As mentioned, the scientists are not exactly sure what is needed for a habitable planet and how everything affects everything else. In the end the user can see if the planet would really be habitable. The programme checks all the selections and gives results showing if it would be possible to terraform the created planet and for how long it would be able to maintain the human race. (E.g. if the planet was near the galaxy centre, an unsteady star could destroy the colony after a few generations.)

9.22 Make a star

Goal: To get people familiar with star forming
Equipment: Empty round shells, fillings with different densities
Interaction levels: Interactive, hands-on

Synopsis:
The stars are formed by condensing from the interstellar clouds, nebulae. When there is sufficient mass in one place the gravity forces the nebula to collapse. If there is enough of this cloud it heats up until the needed limit for fusion reactions will be crossed and a star is born. If there is not enough cloud it will not become hot enough and the object will be called a brown dwarf.

With this exhibit the users are asked to try and create stars. They fill empty shells with different fillings and test what kinds of objects they can produce. After filling a shell it is placed in a “star probe” which measures the size of the shell (there are different diameters) as well as the mass (weight). With this information it will calculate if the object would be sufficient to be a star. (Depending on the fillings it should be considered how massive a filled shell should be to count as one.) The probe could then give information about that particular stellar type. E.g. too light stars would be brown dwarfs, very massive stars blue giants (if the shell was big) or even neutron stars if their diameter was very small and the mass very big. It should be possible to create also planets with no fillings and the smallest diameter shells.

The fillings do not need to be terribly complex. They could include e.g. cotton wool, modelling clay and steel pellets, and the shells are not needed to be filled to the brim.

The idea is to get people thinking that different weights and diameters are connected to the characteristics of a star.

Incentive:
Create yourself a star! Fill the shells with the fillings of your choice and see what kind of an object it would do. Place it to the star probe to find out more about your creation.

9.23 Listen to Space

Goal: To remind people that space is not completely without sounds, even if there is no air where the sound waves could move. There is a lot of radiation, though, and this we can transform into sound
Equipment: Headphones where different sounds are played nonstop
Interaction levels: Non-interactive, hearts-on

Synopsis:
There are sounds in space. And they are incredibly captivating. With this exhibit the visitors can listen to different cosmic sounds with headphones. (Note: Commercial use of NASA material requires a permission. Journalistic, educational and personal use is free.)

Possible sound selections:
- Aurora noises from the atmosphere
- SOHOs collection of solar sounds
- Sounds of Jupiter's magnetic fields
- Symphonies of the Planets - NASA recordings of how planets sound like
- How a pulsar sounds like
- Cosmic background radiation

9.3 Parallel Gamification

To get the visitors engaging with the exhibits on several different levels it is possible to build a “task track” that runs through the whole exhibition. When solving and finishing the tasks of certain exhibits, the user gets a hint as a reward. All these hints point to one word that can be resolved when enough hints are at hand.

Such a track was produced for an amateur astronomy event in 2011 and it consisted of the following hints:

- An astrolabe was provided for the visitors to use and find out which star was in a particular position that day. The star was Betelgeuse, the famous red giant star in the constellation of Orion.
- The spectral lines of hydrogen were presented, emphasis on the H-alpha line. This line is typical for hydrogen and it appears red in the spectrum (wavelength 656,28 nm). The amateur astronomers are familiar with H-alpha through filters which help to enhance its visibility in e.g. astrophotography.
- One hint was on the location, Turku University. In the yard there is a sculpture, Big Bang Echo, that receives and transmits the quiet clutter of the cosmic background radiation. This hinted to the redshift, since because of the Big Bang the universe is constantly expanding.
- There was also a picture of Yuri Gagarin, the first man in space. He was from the Soviet Union and made his flight to space in 1961.

If the visitor could find and solve all the clues, he ended up with the right answer which was *red*. (When I was planning the tasks, I noticed it is much easier if the final answer is something very simple. Then more hints can point towards it.) There was one correct answer and the person was rewarded. He was also very happy and proud that he managed to solve the track.

From the concepts presented here, Charge the Atoms, Spectrum of Light and Solar System Pinball are best suited to be used in such a track. It could present a challenge and motivation for the visitors to really finish the tasks with these exhibits.

It would be good if there was something worth winning in the end, then the track would not need to be terribly easy and those who would manage to pass could be pleased. The best way would be to change the hints every week or every month and publish the ones who succeeded only after the time was up. There would surely still be some exchange with the collected hints, but if e.g. a price was raffled between the ones who answered correctly, maybe it would reduce the eagerness of sharing the information.

10 DISCUSSION

The meaning of this thesis has been to investigate how to plan and create an interactive exhibition. It is a huge task because there are so many different aspects involved. As becomes clear from the theory part of this thesis, there are things to consider from the human behaviour and psychology to the educational message that needs to be conveyed. And it is just the start when the surroundings, functionality, design and experiences are thrown into the soup.

Still, creating exhibitions is one of the most rewarding areas of the interactive media. It challenges the skills of the media professional to the limit but always gives chances to go on trying more and more things. There is a lot of trial and error involved, but learning from one’s mistakes is always the best way to learn. Since interactive exhibits rely not just on the computer skills but also on the understanding of our world and how it functions, a lot of spatial and logical skills are demanded.

This area is something that should and will constantly evolve. The more complex e.g. scientific findings get the harder it is for a common man to understand them. To understand how the world works we need to know its history as well as the present. This is exactly why museums as well as science and heritage centres will be here for a long time to come.

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