INSTITUT FOR NATURFAGENES DIDAKTIK
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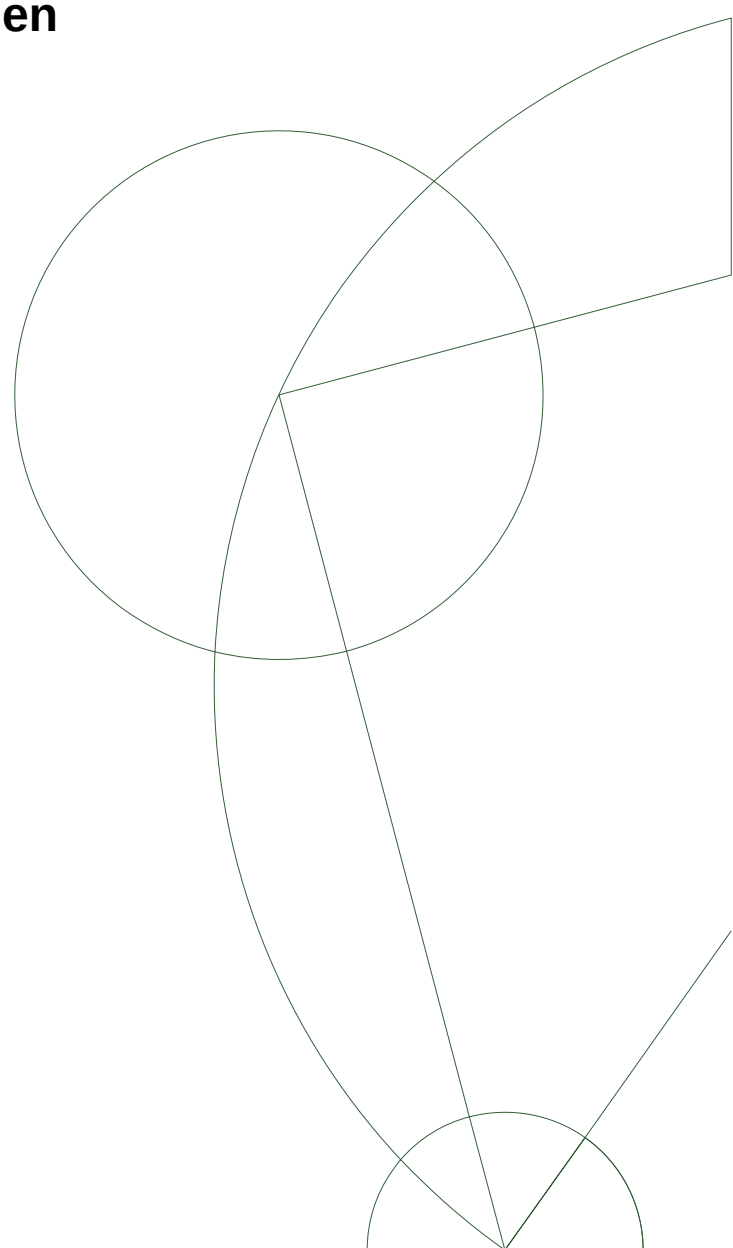
Designing and implementing an engaging learning experience about the electric sense of sharks for the visitors at Danmarks Akvarium

Therese Røndum Frederiksen

Kandidatspeciale



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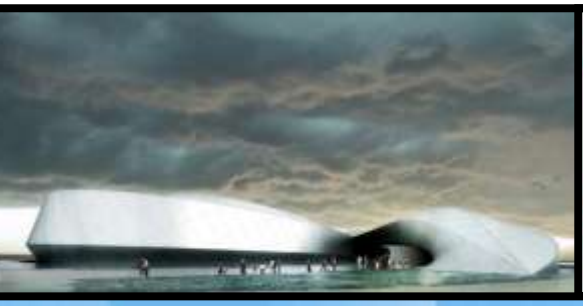
Early inquiry methods have been known since the late 1950s, and now 50 years later their application and popularity is ever growing and the transmission method is one of the most widely used.
I wanted to investigate whether the visitors of Danmarks Akvarium were able to learn more about the electric sense of sharks by one method than by the other. Using the inquiry method the 5 E's I devised an inquiry learning experience which was offered to the visitors of Danmarks Akvarium in two different versions, an inquiry and a transmission version. From this I were able to conclude that the participants in my study who received the inquiry learning experience learned and remembered better within a few hours of them receiving the experience.

Designing and implementing an engaging learning experience about the electric sense of sharks for the visitors at Danmarks Akvarium

- a communication project.



Written by

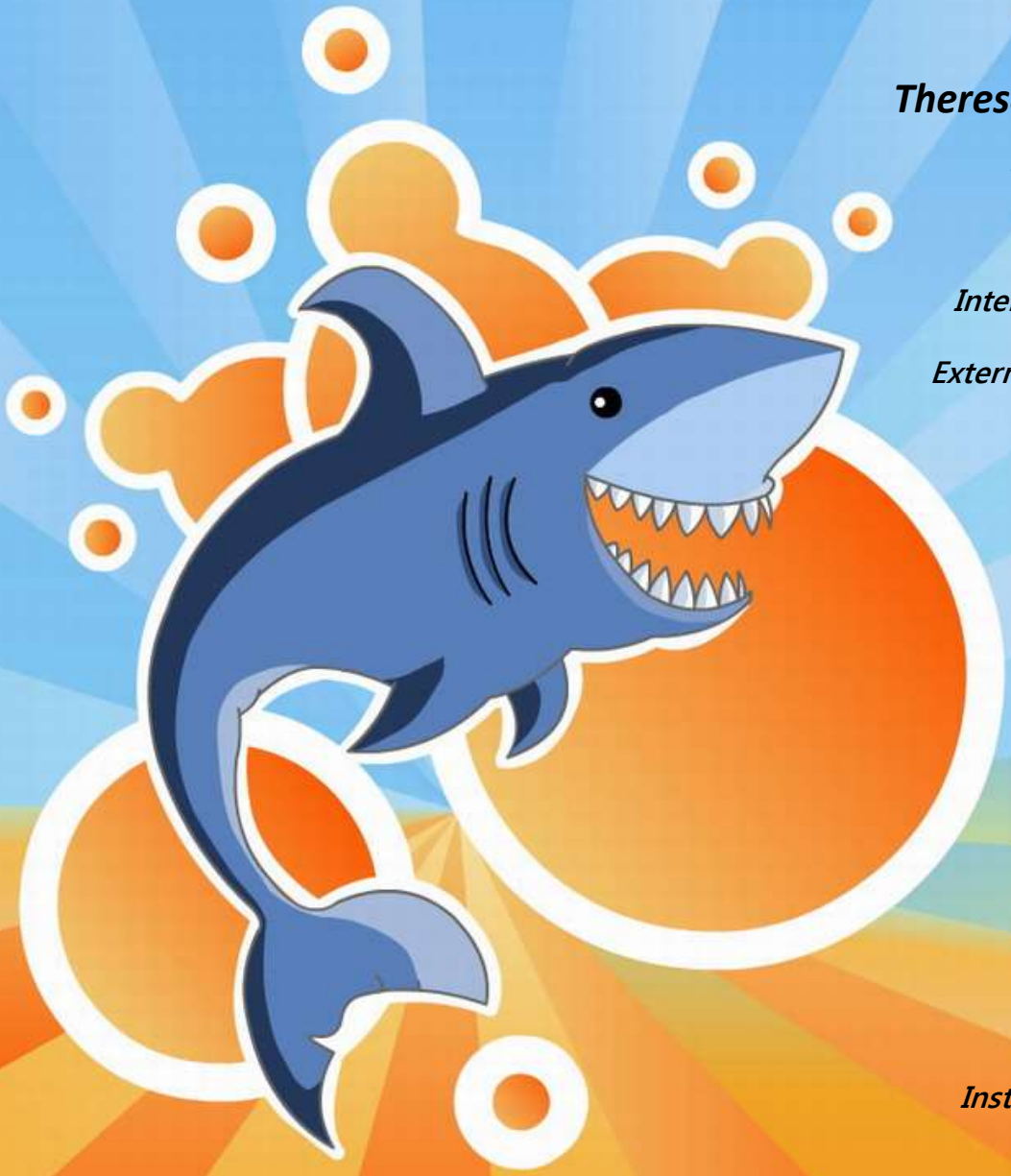
Therese Røndum Frederiksen

Stud. M.sc. biol.

Supervisors:

Internal: Robert Harry Evans

External: Ditte Louise Weldingh



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1.0 Résumé

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Using the inquiry method the 5 E's I devised an inquiry learning experience which was offered to the visitors of Danmarks Akvarium in two different versions, an inquiry and a transmission version. From this I were able to conclude that the participants in my study who received the inquiry learning experience learned and remembered better within a few hours of them receiving the experience.

Keywords: shark, electric sense, inquiry method, transmission method, the 5 E's.

2.0 Introduction

2.1 Knowledge & learning 101

In our time knowledge is seen as a resource, and it is in the interest of the society to cultivate, nurture and extend this knowledge to the people. There can be different motives behind equipping citizens with knowledge, it can be to make them capable of managing occupational functions, but it could also be to give each individual a better understanding of self and their surroundings, including the ability to function in a community with others (Winsløw 2007).

During the last centuries the extension of certain types of knowledge has been institutionalized and professionalized divided and into different disciplines as for instance math and physics. Some types of knowledge, however, are more inherent, and learned without giving it much thought. This applies to everyday knowledge, i.e. knowledge based on everyday experiences, knowledge a person has without having to think about it or even be able to describe it, for instance the ability to judge whether you can cross a street without being hit by a car (Winsløw 2007). The everyday knowledge will usually be integrated into the subject taught, to make it more relatable and the teacher also has to take in to consideration the beforehand knowledge of the recipient. A simple model for what happens in a teaching situation is a "transfer of knowledge" from teacher to student. Naïve as it may be, it is interesting to think of the "journey" of the knowledge, and what happens to it during this transfer, because it isn't just a simple transfer, on this journey the knowledge will be converted so that it fits into the recipients preexisting schedules of beforehand and everyday knowledge (Winsløw 2007).

Those who implement official knowledge can be divided into three main groups: researchers, teachers and students. It is typically researchers who form the new official knowledge; this knowledge is based on their own personal knowledge about the already existing official knowledge. Then it's the teachers job to help the student to personalize the official knowledge, this is done by optimizing the didactic environment. It may be tempting for the teacher to pass the official knowledge directly (transmission) to the student, but this will make it much harder for them to personalize it. Didactical situations are organized so that it allows for the acquisition of a specific official knowledge. In some cases, the transmission of particular information may be enough, but it is important to know in which cases, because the teacher has to ensure that students personalize the given knowledge, otherwise it may be difficult for them to use it in other situations (Winsløw 2006; Tougaard *et al.* 2008). The teachers most principle duty is to take sections of the official scientific knowledge and transform it into exercises and lessons which the students can relate to (Winsløw 2007).

In many areas the human living conditions have been fundamentally changed by scientific discoveries, so much so that we can't remain neutral or independent of them. It isn't a question of for or against, pros and cons, but a question of comprehending and relating to them. Math and science are vital and necessary parts of our culture and society. These subjects have in more ways than many other subjects a much greater everyday usage and this is often an invisible usage which students need to be made aware of. Many people often view math and science with skepticism, without realizing that they actually are everyday scientists themselves. (Winsløw 2007)

This is also why we need a broader prospective when we prepare a lesson, the everyday knowledge is not only used in the classroom but also outside the world of research and teaching, and it therefore has a much greater application because the students use it all the time – in many cases maybe even without knowing it. To make knowledge available to the students it is therefore extremely important to bring their everyday knowledge into the classroom, to give the students a better relation to what they need to learn. If they are forced to consider what they already know from their everyday life, and use this knowledge in new situations, they will be better able to remember but also to explain to others (Winsløw 2007), and the capability of being able to explain what you know to others is one of the best measures of how well it is actually understood.

2.1.1 Construction of knowledge.

When planning a lesson in this day and age constructivist thinking, especially in terms of classical and social constructivism (Piaget and Vygotsky respectively) is often used. Classical constructivist learning in the form of assimilation (new knowledge fit in with existing knowledge) and accommodation (there is a discrepancy which needs tweaking or complete rewriting) is useful because science knowledge must be generated by expansion of existing schedules. The problem with the classical constructivism is the focus of knowledge as a personal construction (Winsløw 2006; Damberg *et al.* 2006). Science learning in particular is socially constructed (i.e. basically social constructivist), since knowledge of this topic is learned through academic discussions and projects, in other words knowledge is formed through social relationships (Winsløw 2006).

For many students, learning science is basically the same as learning a new language; they must learn the academic language code (energy, mass, entropy etc.). This is typically done by imitation of the language use of others (through social relations) until the new language is mastered and can be used fluently (Abell *et al.* 2007; Winsløw 2006). As a teacher it is important to know what resources students have and what their ability to acquire new knowledge through interaction with others (teacher and other students) is. Vygotsky refers to this as the student's "zone of proximal development" (ZPD) and it has been translated into “a social setting can allow many students to stretch beyond the abilities they would have working alone” (Abell *et al.* 2007; Tougaard *et al.* 2008). The intended knowledge must therefore be achieved by adding elements to the students existing resources (or schedules) via an interaction between teachers and peers. By using museum or field trips, it is possible to make science less abstract and more tangible for students and for “private scientists”.

2.2 Learning outside school

Learning outside school is much more important than has been generally recognized. Most people spend more time outside school than in it, and especially now when we have the luxury of learning out of curiosity rather than by necessity, public institutions such as Danmarks Akvarium are extremely important. The main advantage of institutions such as zoos and aquaria’s is that learning is intrinsically motivated, which means that it is controlled by the visitors' own interests and not by force (Abell et al 2007). Another important side of learning outside schools is the fact that it plays a vital role in creating awareness about important issues (Weldingh 2005, unpub.), in the case of

aquaria's it could be overfishing, the importance of predators in ecosystems or new methods which helps protect for instance sharks and turtles from ending up as by catch on a fisherman's hook.

2.2.1 Communication at Danmarks Akvarium, Charlottenlund.

Since its opening in 1939 Danmarks Akvarium has had a special focus on communication to and education of children, and these many years later the percentage of visitors under the age of 18 is almost 50% (Uldahl *et al.* 2006, unpub.). In the mid seventies Danmarks Akvarium alongside Zoologisk Museum and Zoologisk Have were amongst the first to implement the school service (skoletjenesten), which is an offer to provide an insight into our cultural heritage to all undergoing an education by experiencing a personal "hands-on" meeting with history, culture, nature and art (Skoletjenesten 2005; Tougaard *et al.* 2008). As it is today Danmarks Akvarium is rundown and outdated, and since the otherwise beautiful surroundings are protected by law they have become the one thing which keep the aquarium from moving forward (Uldahl *et al.* 2006, unpub.). As seen on figure 1, information to the visitors at Danmarks Akvarium mainly consists of permanent installed signs without an interactive option, and most is written in Danish with only short English translations. The main interactive attractions are the commented fish feedings or history lessons (about the aquria) given twice a day and the touching pool with crabs, flatfish, anemonies and sometimes even small, small-spotted catsharks (*Scyliorhinus canicula*) bread at the aquaria.

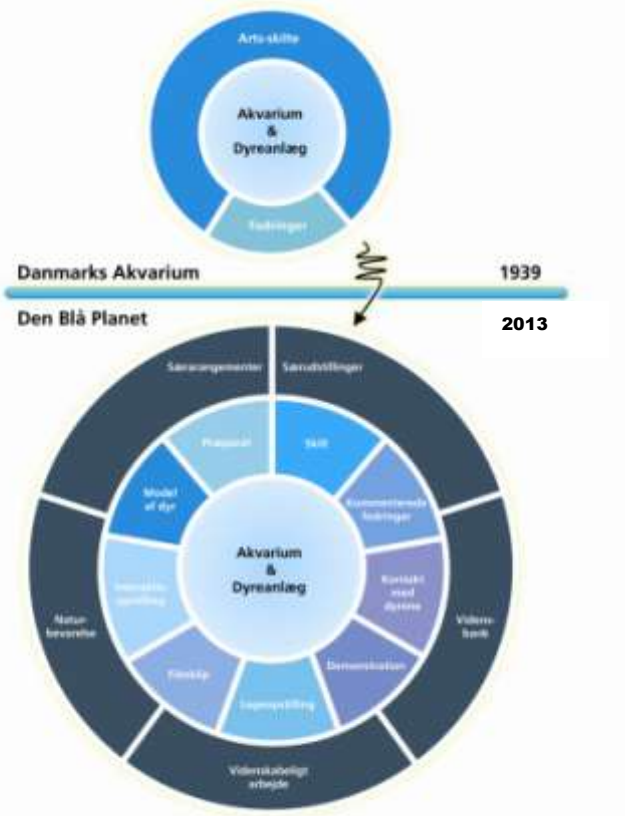


Figure 1: The transformation of Danmarks Akvarium, Charlottenlund into the new modern world-class Danmarks Akvarium in Kastrup.

2.2.2 Communication at the new Danmarks Akvarium, Kastrup

The new Danmarks Akvarium in Kastrup (opening 2013) will of course continue the educational tradition of the old aquarium with the addition of new modernized and expanded ideas, where the barrier between animals and visitors will be broken down even further (fig. 2) The exhibits focus will have a more interactive focus so that the visitors can watch and even play with them (fig. 1 and 2). The tradition of the commented fish feedings, history lessons and the touching pool will of course also be brought to the new aquarium (Uldahl *et al.* 2006, unpub.).

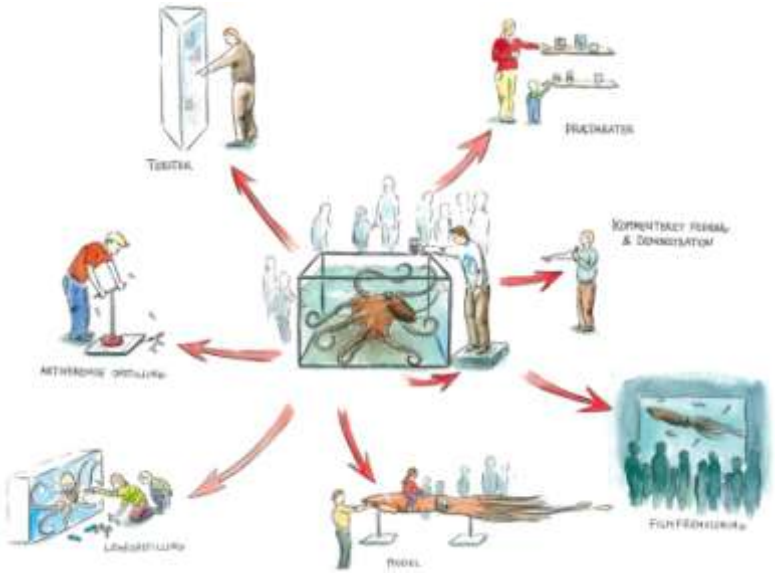


Figure 1: The new Danmarks Akvarium in Kastrup will have a more interactive focus.

2.3 The Inquiry and the Transmission methods

Transmission is basically a transfer of knowledge from a lecturing teacher to preferably passive listening students. Transmission is probably the most widely used teaching method even though it is discouraging for the students and that learning in this way have quite poor results. It leaves no room for the students own thoughts and it becomes so abstract and void of consideration of everyday knowledge regarding the topics, that it thereby leaves the student without the capability of using the topic taught, anywhere else (Damberg *et al.* 2006; Winsløw 2006). The widespread usage of this method probably has to do with the fact that it seems like an efficient and quick way of learning a large curriculum and that many teachers are under an immense time constraints. The teacher controls the situation and the environment is purely didactical with a transfer of knowledge from the teacher to the student and any input from the students either fits into the teachers discourse or is rephrased or corrected by the teacher. This can in turn make the students feel that the teacher is ignoring their contributions and thereby ending up not wanting to say anything Damberg *et al.* 2006; Winsløw 2006).

Inquiry is at the opposite ends of the scale compared to transmission, it is an "investigative" method, an active process of learning where students take part in constructing meaning for themselves. Unlike the transmission method the environment is adidactical as often as possible, and the student instead of the teacher have to be the ones to hypothesize, investigate and explain. With this teaching method, everyday knowledge and misconceptions are bought into the classroom and the students get the opportunity to rephrase and correct their own schedules which offers a much greater chance of personifying the knowledge and thereby the ability to use it in other situations. This in turn will boost the students' confidence and problem solving skills (Abell et al 2007).

The two methods have their strengths and weaknesses; it is true that inquiry helps the students to personalize knowledge, however compared to the transmission method, it is extremely time consuming both to plan (although the plans can be reused for different classes of course) and to carry out. So basically it boils down to quantity vs. quality and passive vs. active learning, and during any topic you will need all of the above to ensure, both that the students have a chance to personalize the knowledge and that the curriculum is met, because this is probably not possible when only using the inquiry method

2.3.1 The inquiry method the 5 E's

The 5 E's is a way of doing inquiry, a way to make sure that the student gets to experience the essence of inquiry (i.e. being scientist in their own way), so basically it is a tool for the teacher so that he or she doesn't get lost along the way. As the name suggests this inquiry method has 5 steps, 5 E's: Engage, Explore, Explain, Extend and Evaluate. The following is a description of each step.

Engage: as the word indicates, this part of the lesson is about catching/captivating the audience, in other words, designing a situation or task which is so interesting that they will want to join the rest of the learning experience. Example: a movie, a task, an exercise or an anecdote that makes people want to know more. It's role is to get the audience to think that it is worthwhile to participate in the experience, and therefore the rest of the lesson has to live up to the promise given in the "engage", otherwise you will lose some of them underway.

Explore: During this section the audience has to do some thinking and problem solving with prompting and guidance from the pilot. The audience must come up with suggestions / predictions on what's going to happen and come up with possible explanations for why. The predictions from

the audiences are very important because it will give them a feeling of having something at stake and they will therefore find the result more interesting. After this they will see what happens.

Explain: Here the audience must assess whether their actual observations of what has happened in the tank, are consistent with their previous predictions and then they must come up with explanations of what happened based on these observations. The pilot will give leading questions such as, What, Why and How. Finally, gaps in audience knowledge will be filled by the pilot using the audience's predictions, observations and explanations to clarify what is actually happening. The pilot must assess how much / little needs to be explained.

Extend: During the "extend" the audience must be able to use the already acquired knowledge in new situations and be able to give a successful explanation of the new situation. In that it requires a certain understanding to use and explain a new situation, the given knowledge will hopefully stick a lot better.

Evaluate: This is an assessment of whether the "student / audience" has successfully understood what the lesson / learning experience was about and whether they learned what they needed. This could be done by, an evaluation, a questionnaire or an interview and can take place after as well as continuously throughout the lesson by observing what is said and done.

2.4 Why is this project so important?

I think there are two main reasons why this project is so important, the first has to do with making official knowledge available to the public, and the second has to do with raising awareness about sharks and how important they are.

It is an art to be able to communicate official scientific knowledge to the general public, scientists are used to reading scientific journals and writing to other scientist, and this is easy enough because we know the language code by heart. Our problem after living and breathing science for so long is how to convey our knowledge to non-scientists in an understandable way, for in many ways we have forgotten the language code outside school. Unfortunately I think many scientists have forgotten the importance of communicating their knowledge to the non-scientist in the public, knowledge has no meaning if it is limited to an elite circle of citizens in the “science-club”. A project like mine is by some thought of, as an easy way to get a good grade because it isn’t

"scientific". However I view it as a huge challenge because I have to try and convey the electric sense of sharks in a manner where anyone from 5 to 95 should be able to understand.

Sharks are feared by many as dangerous man-eating predators, and it is important to show other sides of this amazing animal to ensure their survival. Many shark species are unfortunately endangered and the best way to change this is to change the general opinion in the population. People need to see these animals as much more than fierce predators, they need to care about whether or not they will be around in the future. Aquariums play a huge part in transmission of this message because this is the only way most people will ever get to experience sharks.
Ecosystems, whether above or below the sea are made of webs of interacting species, some of them keystone species, which are fundamental for the system. It has long been thought that sharks play a vital role in controlling the density of other species, however there hasn't been enough research to say that this is actually so (Carrier *et al.* 2004). Even so the removal of a top predator could have greater effects in temperate regions with species poor simple communities compared to species rich complex communities found on many tropical shores (Kaiser *et al.* 2005), simply because in rich communities it is more likely that another species could take the place of the extinct predator. If this is the case it is even more important to raise awareness about threatened shark species, because some of them could be very important for our own ecosystems.

2.5 Description of two of the elements of the learning experiences

2.5.1 The electrical device which can show the electric sense of sharks.

The apparatus is made out of an undressed wood stick with a shelf bracket attached with plastic strips at the bottom end. On the shelf bracket I have attached two plexiglas tubes with wires isolated in the back end into agar made with various amounts of salt (Frederiksen 2011, Unpub). The wires move along the back of the wooden stick all the way up and out of the water where they are attached to a battery (either 1.5 or 9 volt), also attached to the battery is a little light made out of a small diode inside a plastic syringe isolated with silicone so it could shine under water (fig. 1).

Figure 3: Electric apparatus for showing the electric sense of sharks.

2.5.2 Brown-banded bamboo shark (Chiloscyllium punctatum)

The brown-banded bamboo shark (*C. punctatum*, see picture on front page*)* is a bamboo shark in the family Hemiscylliidae (long-tailed carpet sharks) found in the Indo-West Pacific from Japan to northern Australia living in coastal areas around coral reefs and tidal pools near the bottom at depths up to 85 meters (279 ft). Adults are generally less than 1 meter in total length. These sharks are carnivores that should be fed 2-3 times a week; some of their diet includes fresh shrimp, scallop, squid and marine fish. While adults are overall brownish with faint suggestions of bands, the commonly seen juveniles are distinctly barred dark and pale (web link 1; Carrier *et al.* 2004). They are classified as Near Threatened (NT) on the IUCN Red List. The major threats to these sharks are the loss of their habitat, pollution, and hunting (both for aquarium trade as well as food) (web link1).

2.6 Objectives

The main objective is to teach the public that sharks have an electric sense and to find out if it pays to spend time and effort into designing an inquiry lesson or whether the audience learns just as much by the more usual lecture-like (transmissive) method.

The second objective is to increase positive opinions about sharks and increase the appreciation of them among the public. It is very important to give the audience a good, instructive and inspiring experience with the sharks, so that they will leave the aquaria with a more positive attitude toward this animal and hopefully a curiosity which can help ensure that sharks get a higher level of respect in the future, so that we can reverse their current poor treatment.

Based on the research done on learning by inquiry and transmissive methods I hypothesize that the participants who receive the inquiry learning experience will answer my questionnaire more correctly than the participants receiving the transmission learning experience.

The Socratic Method:

He does not lecture

But asks wise and sometimes even wily questions

To his fellow debaters so they themselves realize what it is he wants them to realize!

3.0 Materials and Methods

3.1 Research location

3.1.1 The Danish Aquarium

Danmarks Akvarium (fig. 4) is situated in the beautiful surroundings of Charlottenlund Castle Park. The cornerstone to the aquarium was laid November 4th 1937 and it opened to the public in attendance of the royal family April 21st 1939 (Schiøtz 1980; web link 3). Danmarks Akvarium is an independent institution, and it does not rely on public funds. It is a tradesman fund, with a purpose of communicating knowledge about animal life under the sea to a broad audience. In addition the aquarium also pays particular attention to being a benefit for education and providing animals for research (Danmarks Akvarium 2010).

Figure 4: The Danish Aquarium

3.1.2 Placement and description of my study site at the aquarium

My study was conducted at tank number 30 (fig. 5 & 6) inside the aquaria. There are some challenges when doing a study like this, the most prominent are that it is quite dark and the acoustics are very bad. The tank has six brown-banded bamboo sharks (*C. punctatum*) and the apparatus I have made to show the electric sense is attached inside the tank (fig. 6) during each learning experience, this, however is purely for illustrational purposes as it is not turned on. The following equipment is also present during each experience:

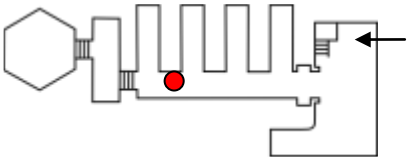


Figure 5: floor plan of the aquaria. Arrow marks the entrance and the red circle marks tank number 30.

Figure 6: My set-up for the learning experiences at tank number 30. Arrow marks the electric apparatus.

1. Whiteboard to do the sense exercise on.
2. A small copy of the electric apparatus attached in the tank.
3. A computer to show a video of the sharks attacking and pictures of the electric sense organs (ampullae of Lorenzini).
4. A small gift basket with for the audiences who choose to answer the questionnaire.
5. A pamphlet about sharks I have made for the participants to learn more about the sharks.

3.2 Inquiry learning experience and questionnaire trials

3.2.1 Testing the original idea of the inquiry learning experience

The original idea of the learning experiences (both inquiry and transmission) was that they were supposed to be plenum experiences with different individuals and family groups working together and bouncing ideas off each other. Each learning experience were supposed to be announced over the speakers where after the audiences had to make their way to tank 30 to meet the "pilot of the day" (either Anders or Lasse, the two pilots at the time). Since the transmission type lesson is the one they normally give at the aquaria, we knew that it would probably work; we therefore wanted to test whether the inquiry method would also work.

We tried the inquiry learning experience a couple of times, and we just could not make it work. Most of the audiences disappeared as soon as the word "participate" was mentioned, no matter how much fun we made it sound, and those who stayed where not particularly interested in actually participating. One of the problems were that if the pilots caught the kids' attention, the adults did everything but listen (look at their watch, yawn, stare at the ceiling etc.) and if the pilots caught the adults' attention, the kids got bored and the adults eventually ended up leaving because of that. The main issue, however, were that the pilots in most cases ended up giving the answer themselves because no one else would, and this makes to inquiry learning experience to much alike the transmission, and it would therefore be impossible to test whether there actually is difference between the two methods.

I therefore chose to change the learning experiences so that instead of doing them once or twice a day in plenum I where to stand by the tank with all my equipment for two hours in the morning (10-12 am) and two hours in the afternoon (0.30 - 1.30 pm) only separated by a 30 min lunch break. This allowed me to do the learning experiences (both transmission and inquiry) with one family at the time and luckily the audiences responded a lot better to this method than the original.

3.2.2 Testing the original questionnaire

In order to test whether the audiences would read and understand the questions I had made for my questionnaire correctly, I contacted about 20 people I knew and thought might want to help. I chose people with very different backgrounds to make sure that I would get as varied responses as possible. The 10 who replied had the following backgrounds: two medical students, a biology student, a primary educations teacher, a nurse, two with a degree in the field of environmental

development, a cleaning man, one with an engineering degree in energy efficient building construction and one with a degree in clothing design.

I used these answers to assess which of the questions in the original questionnaire (appendix 1a) needed tweaking or if any needed complete rewriting. I told the participants to make a short remark about how they understood each question and then to answer immediately without thought or consideration, because this is the most likely way the audiences will answer. They were also encouraged to think of other ways of asking the questions. I chose to change the questions based on two conditions:

1. Two or more people made the same comment / mistake when commenting / answering a question.
2. If I was in doubt about a question and one or more people had made a comment / mistaken answer which corresponded to the doubts I had.

Based on the answers I ended up changing some of the questions and the order of them. The two illustrations and the text of Q1 & Q5 were specified to avoid confusion. Q9 was divided into two different questions (e.g. Q12 & Q16 appendix 1b), so that questions about sharks in general and questions about the visit were separated. Overall content and process questions (explanation will follow) were placed in the beginning and attitude questions towards the end, both to make the questionnaire more cohesive but also to make it easier towards the end, where the audience probably wants to be done.

3.3 The pre learning experience

3.3.1 The welcoming poster

To make sure that people knew who I was when they arrived at my "station", I placed a colorful and eye catching 50x50 cm poster (fig. 7 and app. 2) in the lobby, welcoming them to Danmarks Akvarium. In the bottom right corner I made room for a small laminated sign telling when I would be at the tank (either 10-12 am; 0.30-2.30 pm; or both) and it was also noted that if they participated in the learning experience and answered a short questionnaire they could win a guided tour behind the scenes of the aquarium with Anders, the aquarium pilot (app. 2).

Figure 7: Welcoming poster

3.3.2 The Shark Quiz

The poster encouraged the visitors to answer a little "Shark Quiz" (fig. 8 and app. 3) where they had to draw a line between a picture and a number to illustrate which of the pictured objects killed that amount of people each year. On a shelf underneath I had placed an answering box, and I noted on the poster that they would get the answer to the Shark Quiz after participating in the learning experience. This little exercise was thought as a pre learning experience "Engage" session, something to make the audience want to participate, because they thought it interesting but also as an incentive because they wanted the answers to the Shark Quiz.

Figure 8: Shark Quiz

I didn't get much of a response on either the poster or the Shark Quiz and I therefore tried placing it different places in the lobby to see if the visitior would pay more attention to it (app. 2 for the placements).

3.4 Description of the learning experiences

As mentioned in the introduction I will be using a particular inquiry method called the 5 E's (Engage, Explore, Explain, Extend and Evaluate). Although this is an inquiry method I will be following the exact same steps and saying and showing exactly the same things during the transmission learning experience, the only difference is that the audience will NOT be actively participating. The following is a detailed step by step description of the two types of learning experience, e.g. inquiry and transmission. I will be describing each of the 5 E's one by one first with the inquiry and then with the transmission.

The way I recruit audiences is by standing by the tank, looking inviting and smiling so that people do not feel intimidated, and then asking the ones who stop or walks by the tank if they want to either hear about (transmission learning experience) or participate in (inquiry learning experience) an interesting and fun learning experience about the senses of the sharks.

3.4.1 Engage

3.4.1.1 Materials

A whiteboard with the following written on it "COME AND PARTICIPATE IN A FUN EXPERIENCE" or "COME AND HEAR ABOUT THE SHARKS SENSES" for inquiry and transmission respectively (fig. 10 & 12). On the whiteboard there are also magnetic pictures of a

shark and a fish and pictures of 4 of the sharks senses: vision, taste, smell and hearing (fig. 9). During inquiry these magnetic pictures are placed randomly in the bottom of the board, and during transmission they are placed correctly under each number. The audience will not yet be told about the electric sense, and I have deliberately omitted the sideline and the sense of touch because these would only confuse the situation. The sideline sense would need some additional explanation and the sense of touch would have to be placed in the same spot as the sense of taste. After a few learning experiences I also chose to write on the whiteboard "Help the shark catch the fish" (inquiry) or "This is how the shark uses its senses to catch the fish" (transmission), and this seemed to make the audiences more interested, and some even came to me and asked what I was doing and if they could try.

Figure 9: Magnetic pictures of those of the sharks senses used in the learning experiences

3.4.1.2 Inquiry

When a group/single person agreed to participate I started by showing the whiteboard, and asking them to help the shark catch the fish by placing its senses in the order they thought the shark would use them to hunt (fig. 10). They had to place each of the following senses, vision, taste, smell and hearing under a number from 1-4. They were told to place them so the one with the greatest range was under 4 and the one with shortest range was under 1. If there were older children (6-10 years) I asked them to help place the senses, with their parents/grandparents help, in order to make them feel included, but also to keep their attention, because if this failed their parents would leave as well. When they were done placing the senses I asked them to shortly explain the order they had chosen from 1 to 4, and I guided them by asking open and encouraging question about each placement. The following are examples of questions based the order: taste (1), vision (2), hearing (3) and smell (4).

Figure 10: Whiteboard used during the inquiry learning experiences.

- Why did you place the sense of taste as number 1?
- Why is vision number 2 and not further away?
- Why did you place hearing and smell furthest away?
- Why is smell number 4 and not hearing?
- What do you know about the sharks sense of smell?
- Do you know anything about sound in water?

These questions were supposed to make people think about their choices and give them the opportunity to come up with their own explanations, which is what inquiry is all about.

After their explanations I filled in the gaps in their knowledge and corrected the order of the pictures if it was wrong. I made sure to use their statements when I was telling them how it actually worked and in which order (for correct order see fig. 11). After each inquiry learning experience I either took a picture or noted which order the group had chosen.

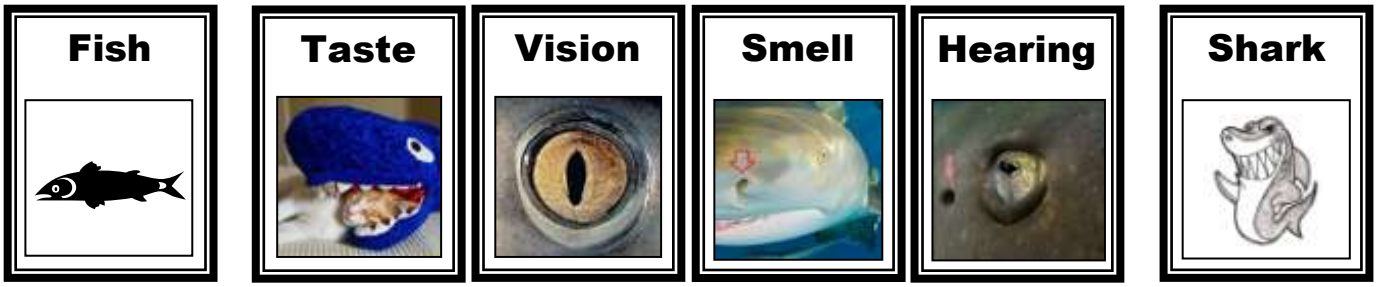


Figure 11: Correct order of the sense

3.4.1.3 Transmission

During this experience the magnetic pictures of the senses are as mentioned placed in the correct order from the beginning (fig. 12) and the audience will only be told why they are supposed to be placed like this. I did however use what I had learned during the inquiry experiences to tell them what other people thought. For instance I told them that I had made an enquiry at the aquarium about how people would place these senses and that most placed them as follows: taste, vision, hearing and smell. I did this to make the knowledge more relatable, and since this topic isn't exactly something most people know about there was a real chance that I might lose them underway, and by telling them of other peoples mistakes they would know that they weren't alone in not knowing and would be more willing and open to the knowledge. I realized that this could backfire because they might remember better, but I didn't want to give them a disadvantage from the beginning, I really wanted to get their attention.

Figure 12: Whiteboard used during the transmission learning experiences.

3.4.1.4 "Must say" during Engage (both inquiry and transmission)

Taste (0 meters): The shark has to be close enough to bite to taste its prey, and therefore it is the sense placed under 1 in the exercise.

Vision (up to 100 meters): Sight is a direct sense and is therefore limited by how far the shark can actually see and is also dependent on water clarity and the presence of other plants and animals.

Smell (over 100 meters): Smell spreads very diffusely in the water and it can be difficult for the shark to follow a scent trail when it is close to the source. The shark follows the nostrils which the odor reaches first (not the nostrils where the concentration is greatest!), The reason can be found in odor dispersion in water, which can be compared with a little smoke from a chimney - a mixing off high and low concentrations in arbitrary distance from the source .

Hearing (more than 1 kilometer): Sound travels 4 times faster in water than in air, sound can be heard at much greater distances, but it is the same reason also extremely difficult to locate sound source if you are close. When we assess where a sound comes from we do it by instinctively knowing which ear the sound reaches first, this can be extremely difficult under water if you are close to the source because the sound reaches both ears at the same time.

3.4.2 Explore

3.4.2.1 Materials

During explore I will be using the small copy (fig. 13) of the electric apparatus I have made to show the electric sense of the shark and a laptop computer with a film of the sharks responding by stopping directly in front of the tubes and turning the snout straight towards the ends of the tubes (for movie clip see DVD app. 1).

3.4.2.2 Inquiry

I began the Explore section of the inquiry learning experience by telling them that I would now show them a sense that humans do not have, after which I showed them the copy of the electric apparatus (fig. 13), and explained that the reason why it was dripping was that the gel - agar - inside the tube had to be wet. I also told them that it was completely harmless and that you could actually buy it in health food stores for consumption. Then I asked them to look closely and to tell me what they recognized step by step from top to bottom. After the first looks and comments I turned the apparatus on by putting the wire cap on the battery so they could see the light turn on. When they had recognized the battery, light, wires and that the wires went into the strange tubes at the bottom, I told them that the light was purely for the audiences so that they could see when it was turned on, and that it was the two tubes in the bottom the shark were supposed to react to, then I asked what they thought the apparatus did. This question seemed to

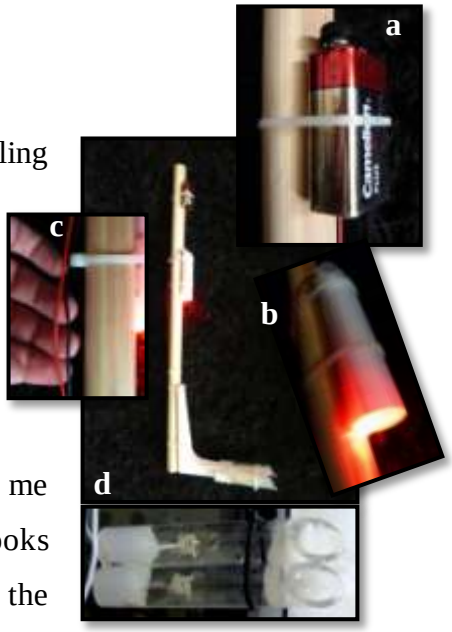


Figure 13: Picture of the copy with large images of its parts. a) 9 volt battery b) light c) wires d) agar filled tubes with exposed wires isolated inside.

baffle or bewilder many of the participants and many said that it had something to do with sound where after I reminded them, that this apparatus didn't illustrate any of those senses we had just been playing with during Engage. If they couldn't come up with an answer I asked them if they had seen the electric eel and what this fish could do. Then I told them that my apparatus was kind of like a homemade electric eel though nowhere near as powerful. I also explained the reason for casting the wires into ager; if I just lowered the wires into the water and turned on the electricity on they would corrode within seconds and bobbles of chlorine gas would be released, and this is not good for the sharks. Then I asked them to predict how the shark would respond to the electric field after which I showed them a movie clip of a shark response (DVD app. 1).

3.4.2.3 Transmission

Just as during the inquiry experience I began the Explore part of the transmission experience by telling them that I would now introduce them to a sense that humans do not have, and then I showed them the apparatus and explained about the wet and edible agar. Then, instead of asking them to tell me what they could recognize on the apparatus I told them what the different parts were and turned on the light and told them that it is kind of like a homemade electric eel and that the light was only for the audiences and not the sharks. They also received the explanation about the function of the agar. Just like I did during the Engage I also used what I had learned during inquiry by telling them that I had made en enquire about how the sharks would react to the electric field and that most had answered that they would be afraid of it. Then I showed them the movie clip of a shark response (DVD app. 1).

3.4.2.4 "Must say" during Explore (both inquiry and transmission)

- The gel is Agar which is harmless and edible.
- The light is purely for humans, it is the tubes the sharks must react to.
- The tubes illustrate a sense we do NOT know from humans.
- The apparatus is kind of like a homemade electric eel.
- Before the movie is shown they must be aware that it is the electric sense it is showing.

3.4.3 Explain

3.4.3.1 Materials

A laptop computer with pictures of the electric sense organs (Ampullae of Lorenzini) of a shark and a ray (fig. 14a-b or app. 4 for larger images) as holes in the skin around the snout and mouth.

3.4.3.2 Inquiry

This part of the learning experience takes place directly after they have seen the movie clip. I begin by telling them the following, depending on their predictions:

A) Yes, you were correct, the sharks found the electric field interesting, however I have actually seen the opposite response as well, where the sharks avoid the tubes by swimming around in a well defined circle. This all depends on how much salt I add to the ager, because more salt equals more electricity. If I put a lot in they swim around and vice versa.

B) The sharks actually found the electric field interesting, however, as you predicted I have actually seen the opposite response as well, where the sharks avoid the tubes by swimming around in a well defined circle. This all depends on how much salt I add to the ager, because more salt equals more electricity. If I put a lot in they swim around and vice versa.

Then I asked them two open and encouraging questions and whatever explanation they couldn't come up with themselves I gave them.

Question: Do you know of anything in the human body which makes electricity? (Heart, muscles while in moving).
Explanation: The fish's heart and muscles also make electricity when they swim, and the sharks can sense this.

Question: Why then do you think the sharks swim around when there is more current but are interested when there is less? (More current = big fish; less current = small fish).
Explanation: The weaker current imitates that of a prey size fish which awakens the sharks hunting instinct, and the stronger current could perhaps electrically look like a large fish either

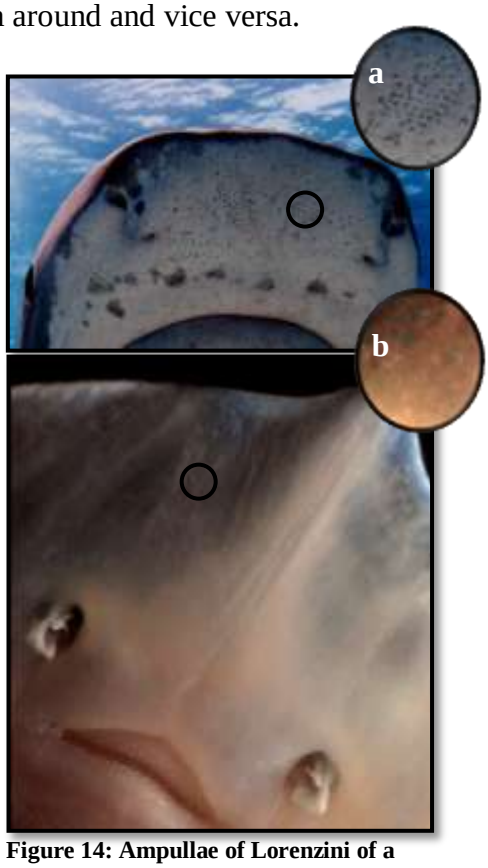


Figure 14: Ampullae of Lorenzini of a shark (a) and a ray (b).

too big to eat or a larger predator hunting the smaller shark which would make the shark escape.
Then I turned their attention to two pictures of the electric sense organs of a shark and a ray on the computer to show them how the sharks can sense the electricity in their surroundings. I showed them the pictures (fig. 14a-b; app. 4) and pointed out all the small holes in the skin, and explained that the shark continuously could sense electricity in each of these holes and thereby constantly be aware of any electricity in the vicinity.

3.4.3.3 Transmission

As with the inquiry experience this part began directly after the clip of the sharks responding and I started by telling the following:
Unlike what most people had guessed the shark actually found the electric field interesting, however, I have actually seen the opposite response as well, where the sharks avoid the tubes by swimming around in a well defined circle. This all depends on how much salt I add to the ager, because more salt equals more electricity. If I put a lot in they swim around and vice versa.

Explanation: When we move our heart and other the muscles make small electric fields, this is the same for fish, they make electricity when they swim, and the sharks can sense this. The reason why the shark is interested when the current is weaker is because it imitates that of a prey size fish which awakens the sharks hunting instinct, and the stronger current could perhaps electrically look like a large fish either too big to eat or a larger predator hunting the smaller shark which would make the shark escape.
Then, just like during inquiry, I turned their attention to two pictures of the electric sense organs of a shark and a ray on the computer to show them how the sharks can sense the electricity in their surroundings. I showed them the pictures (fig. 14a-b; app. 4) and pointed out all the small holes in the skin, and explained that the shark continuously could sense electricity in each of these holes and thereby constantly be aware of any electricity in the vicinity.

3.4.3.4 "Must say" during Explain (both inquiry and transmission)

- Salt equals more electricity / stronger electric field.
- Heart and other muscles make electricity while in motion (humans and fish)
- More current = big fish (predator, to big prey); less current = small fish (prey)
- Holes in the skin continuously sense electricity in their vicinity

3.4.4 Extend

3.4.4.1 Materials

During this part of the learning experience I used the last magnetic picture on the board, that of the electric sense (fig. 9), and two batteries, a 1.5 volt and a 9 volt battery (fig. 15).

Figure 15: The two batteries used during the learning experiences

3.4.4.2 Inquiry

The final step in the actual learning experience is for the participants to place the electric sense amongst the other senses from Engage on the whiteboard. They are instructed to either place it beneath one of the other senses or in between and to explain why based on everything they have seen and heard during the learning experience. If they placed the electric sense wrong I corrected them and explained that as they saw in the movie clip the shark was fairly close before it responded. I also explained that big sharks has to be within about a meter and smaller sharks within 30 cm to respond to the electric field of their prey, and that the reason why there is such a big difference between smaller and bigger sharks could be found in the fact that most big sharks hunt bigger prey which also have a larger electric fields and therefore can be sensed at a greater distance.

As a small farewell game I showed them two batteries (fig. 15) and asked them whether they could guess if the sharks would be able to sense either of the two or maybe even both? After their guesses I explained that the sharks would easily be able to sense both and if I turned the 1.5 volt battery down 100.000.000 times (e.g. 0.015 μV) they would still be able to sense it!

3.4.4.3 Transmission

This part of the transmission learning experience is basically exactly the same as the inquiry, the only difference is that they do not get to place or explain the electric sense, and they are not asked whether they think the sharks can sense the two batteries, they are just told that they can and how well.

3.4.4.4 "Must say" during Extend

- The sharks have to be fairly close to sense the electric field (big sharks within 1 m.; small sharks within 30 cm.)
- The sharks can sense both batteries and 100.000.000 times less than the small

3.4.5 Evaluate

The evaluation in this case is a questionnaire (app. 1b), and it is exactly the same questionnaire for both inquiry and transmission. The questions are content, process and attitude questions and they are designed to assess whether the inquiry group OR transmission group remember better (content), are better at solving unknown problems (process) and have a better attitude than the other, it could off course also be that one group are better at only one of the before mentioned skills than the other.

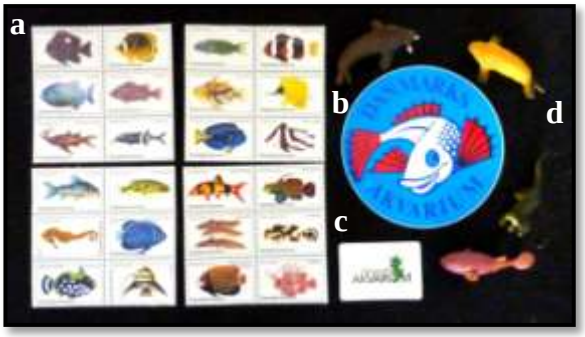


Figure: 16: Gifts to choose from a) different types of stamps, b) Danish Aquarium sticker, c) Danish Aquarium magnet d) many different small plastic animals.

Content questions: Q1; Q2; Q7

Process questions: Q5; Q6; Q8; Q9; Q10; Q11

Attitude questions: Q3; Q4; Q12-Q16

During the original plenum learning experience Q11 was supposed to be a content question because we were supposed to discuss the problems with biological experiments, but in the actual learning experience it ended up as a process question because it proved too much.

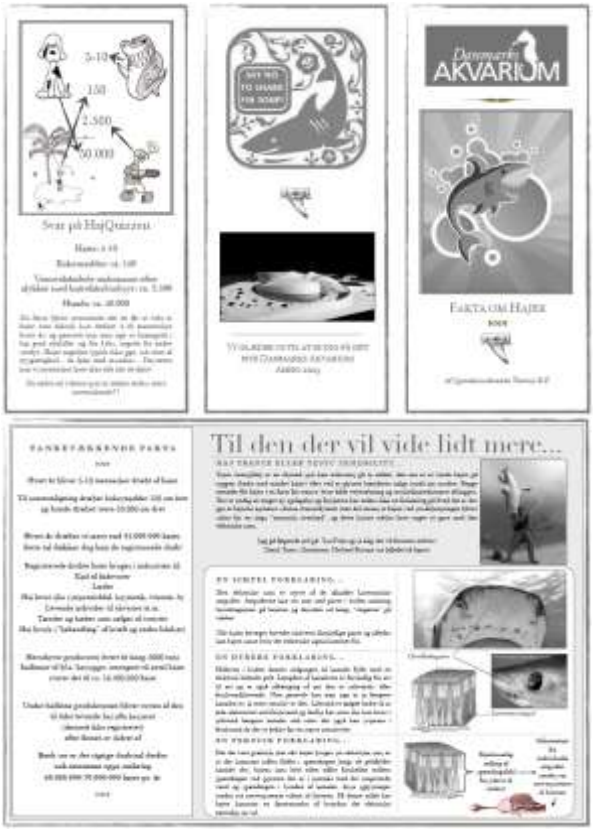


Figure 17: Shark interest pamphlet. Top = outside, bottom = inside

3.4.5.1 "Must say" during Evaluate

I ask everyone who endures to this point whether they would be willing to help me with my project. If they accept, I emphasize that I am aware that the questions are difficult, but that this is because I need to see if I get better at doing these exercises along the way. Then I tell them that they will come across questions about which I haven't said anything at all, and that this is on purpose because I need to know whether it is possible to figure out some of the answers because we are going to use their answers to assess what needs to be said/written at the new Danmarks Akvarium in Kastrup, to make sure that future audiences can follow as well as they had. Then I finished by saying that they could either hand it back to me when

they were done or leave it by the front desk for me to pick up later. As an incentive to answer I gave everybody the chance to choose two things from a little "gift basket" (fig. 16), and everybody where also handed a little shark interest pamphlet (fig. 17 and app. 5), because as I said, I had so much more I wanted to say about sharks. The answer to the Shark Quiz could also be found in the pamphlet. The participants were also informed that they could win a guided tour behind the scenes of the aquaria by answering the questionnaire and writing their e-mail address.

3.5 Data analyses

To keep track of how many questionnaires I handed out and received back I marked a number in the corner and the transmission questionnaires were also marked with a T for transmission.

3.5.1 Data processing

3.5.1.1 Open questions (Q2, Q6, Q7, Q9, Q10, Q11).

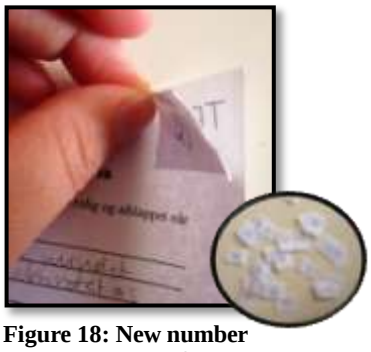


Figure 18: New number 21 taped on top of the old number 27T.

To score the open questions I used the Rubric-method and wrote three answers (without having read the answers of the participants) for each and added a zero category for those who had either, not answered the question, answered with a question mark or answered completely wrong. My answers were made so that the simplest answer got 1 point and the best answer got 3 points. I also wrote a few "buzz words" which could be used when in doubt to figure out if an answer should receive a higher score. To make sure I wouldn't unconsciously give the inquiry group a higher score I mixed the questionnaires and at random taped a new number between 1 and 33 on the questionnaires (fig. 18). The following is an example of answers I have written for question 2 (the notation // divides it into different answers which all will receive the marked number of points separately):

Question 2:

0. No answer // ?? // wrong answer
1. It is the strongest senses
2. Sound ad smell spreads different in water, and it can be difficult to decide where the source is, it is easier on greater distances // Sound travels 4 times faster in water than in air // The sharks sense of smell is extremely efficient but scent spreads like smoke from a chimney.

3. Smell and sound are mainly used on greater distance; this is because they are not as reliable up close. Sound travels 4 times faster in water than in air and if the shark is too close to the source at can be difficult to tell where the source is because the sound reaches both ears at ones. The sharks incredible sense of smell but smell spreads very diffusely in water (high and low concentrations randomly mixed at distance from the source) therefore the shark follows the nostril which the smell reaches first, in the same way as sound, and just like with sound it can be difficult because the smell reaches both nostril at the same time.

Buzz words: Smell spreads like smoke from a chimney // sound travel 4 x faster in water // sound or smell reaches both left and right at the same time

3.5.1.2 Closed questions (Q1, Q3, Q4, Q5, Q8, Q12-16)

Question 1:

To analyze question 1 I scored each answer by how many correct placements they had from 1-5. If they placed all senses correct they got five points, 4 correct 4 points and so on. I made two assumptions when analyzing this question.

1. The one who answered the transmission questionnaire 12T forgot to write the electric sense, but the other 4 were in correct order, except for the fact that vision, smell and hearing had moved forward a spot (because of the lacking electric in position 2), however I decided to give the answerer 4 points instead of 1 because they actually were in the correct order.
2. The one who answered the transmission questionnaire 28T had listed all of the sense in correct order, but in the opposite direction, so that hearing = 1, smell = 2, vision = 3, electric = 4 and taste = 5. Here I decided that it was probably a reading error and gave the answerer 5 points instead of 1 (vision is correct because it is in the middle whatever way you look at it).

Question 3 & 4:

To analyze question 3 and 4 I gave 1 point for answering Yes and 2 for answering No

Question 5:

To analyze question 5 I gave 1 point for answering electrode and 2 for answering fishpiece

Question 8:

For this question I have made another assumption. Two of the people answering the questionnaire after an inquiry learning experience answered this question by making two answers instead of just

one, I decided to give each of these answers a half when calculating the percentages and when calculating the significance they were each given the point of their position. Just to make sure, I also tried removing them entirely from the dataset which only caused a more significant p-value so I feel confident in my choice because I don't feel that I can justify removing them.

To analyze question 8 I gave the following points for the following answers:

1 Point: just beneath the surface

2 point: Midway between the surface and the bottom

3 Points: On the bottom

4 Points: In the bottom

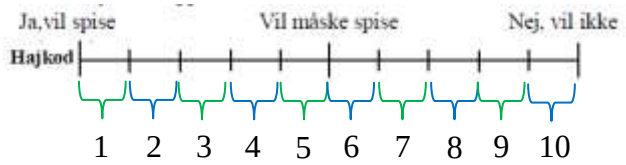
Question 12 & 16:

I chose to analyze these questions based on the most positive statement. Basically the most positive of the statements would get 5 points and the least 1 point, this also means that I will reverse the negative question (i.e. I am afraid to swim with sharks), like follows:

Statement:	Disagree	Neutral	Agree
We should do more to protect sharks	1	3	5
Generally sharks should be protected by law	1	3	5
Sharks are intelligent animals	1	3	5
Sharks are typically dangerous	5	3	1
After this lesson I want to know more about sharks	1	3	5
I am afraid to swim with sharks	5	3	1
The visit/lesson has been: Instructive	1	3	5
The visit/lesson has been: Exiting	1	3	5
The visit/lesson has been: Fun	1	3	5
The lesson has been: Easy to understand	1	3	5

Question 13-15:

I have scored these questions by giving them points from 1-10 depending on where on the scale they have placed their mark. As the drawing shows they receive 1 point if the place the mark within or on the first crossbar, and 2 points if it is within the second line or on the second crossbar etc.



I have also analyzed how many would consider eating/buying shark items in the future, this has been done by calculating how large a percentage received a score 5 of points or below in sharkmeat, sharkfin soup and shark souvenirs for both the transmission and inquiry group individually.

3.5.1.3 General analysis of the questionnaire:

How many answered all questions, open questions and closed questions:

The percentage of "No answers", "question marks" and "answers" where found by counting how many questions in total where left blank / marked with a question mark / answered (respectively) out of the total number of questions.

Which group had the most correct answers:

I have assessed how large a percentage of correct answers each group received by using the following data:

Q1: How many got max score from each group

Q5: How many answered "electrode" from each group

Q8: How many answered IN the bottom from each group

Q13: How many got 10 points in both at the same time "sharkmeat" and "sharkfin soup".

Q14: How many got 10 points in "shark souvenirs"

All Open questions: I calculated the percentage of all scores above 0 points for each group

Q3+4, Q12, Q15+16: Not included because no answer is more correct/incorrect.

3.5.2 Statistics

For the statistical analysis I used "GraphPad Prism 5 – trial version 5.04". If you look at the general population in Denmark, my participant probably do not fit a Gaussian distribution because the visitors at the Danish Aquarium are a quite skewed section: Families with kids up to about 10 years, daycares, kinder gardens, school classes and young couples without kids (based on personal observations when standing by tank 30). However I have taken the liberty of assuming that my participants fit a Gaussian distribution within the visitors of the aquarium, so even though the data do pass a normalcy test I have chosen to do both the parametric unpaired t-test and the non-parametric Mann-Whitney U on much of my data because I thought it interesting to compare both the means and the medians. I have used a D'Agostino & Pearson omnibus normality test to test for normalcy, however none of the closed questions (Q1, Q3, Q4, Q5, Q8, Q12-16) fitted a Gaussian distribution, but all of the open questions did (Q2, Q6, Q7, Q9, Q10, Q11).

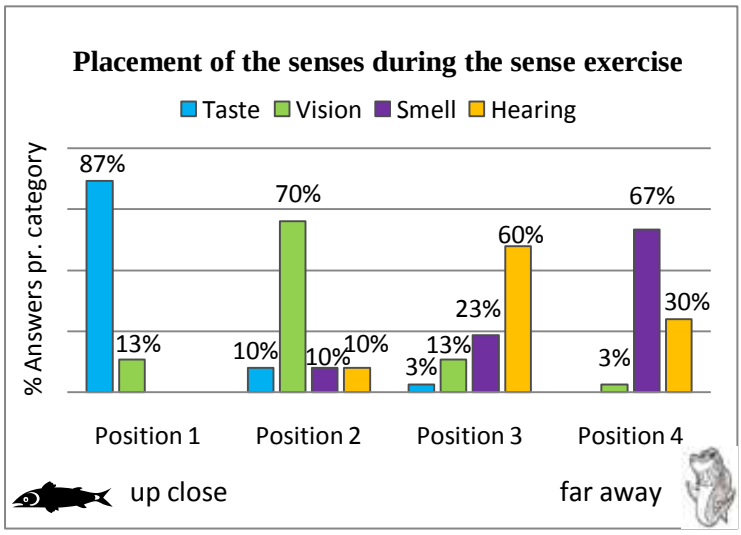
4.0 Results

4.1 The welcoming poster & the Shark Quiz

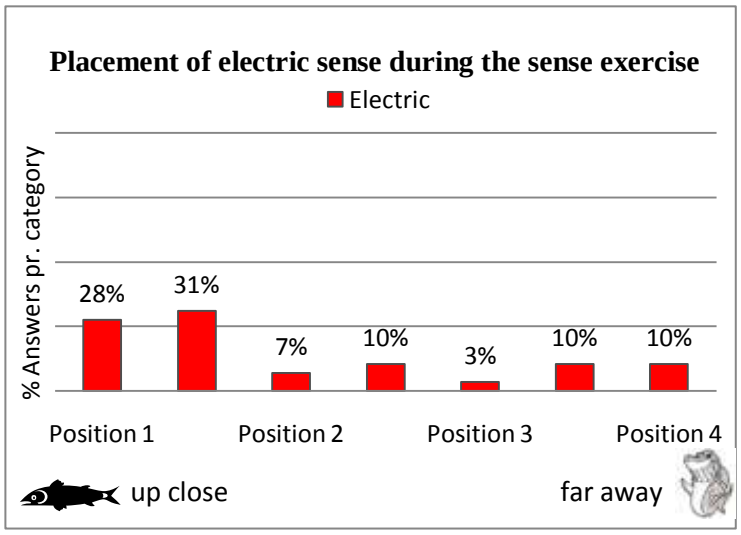
The welcoming poster did not get the response I was hoping for, most of the participants hadn't even seen it, and the ones who had, had only seen a glimpse of it and not actually read the poster nor done the Shark Quiz. I was lucky if 2 people had answered the Shark Quiz in any one day and most days I got zero replies. One day there was suddenly a bundle of 10-15 answers, but this turned out to be from a group of 5 and 6-year-olds who had participated in the learning experience, they had found the poster in the lobby afterwards and all of them answered. I have not included the responses from this exercise because they are mostly the result of the aforementioned group of 5 and 6-year-olds.

4.2 Placement of the senses during the inquiry sense exercise

As you can see on graph 1 most participants agree on the following order from 1 to 4: Taste, Vision, Hearing and Smell. The placement they most agree on is taste in position 1 by 87%, They do not entirely agree about the other three senses however 70% would place vision in position 2, 60% would place hearing in position 3 and 67% would place smell in position 4. Graph 2 shows the placements of the electric sense during the sense exercise, these guesses are not as well defined as the ones for the other senses (graph 1), however almost 2 out of 3 (59%) chose to place it in position 1 or midway between 1 and 2.



Graph 1: Percentage of answers in each category



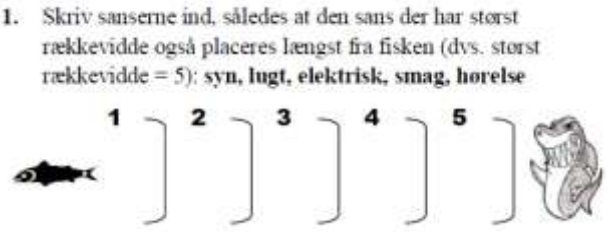
Graph 2: Percentage of answers in each category. A bar in a middle position corresponds to those who placed the electric sense between two of the other senses.

4.3 Results of the questionnaire

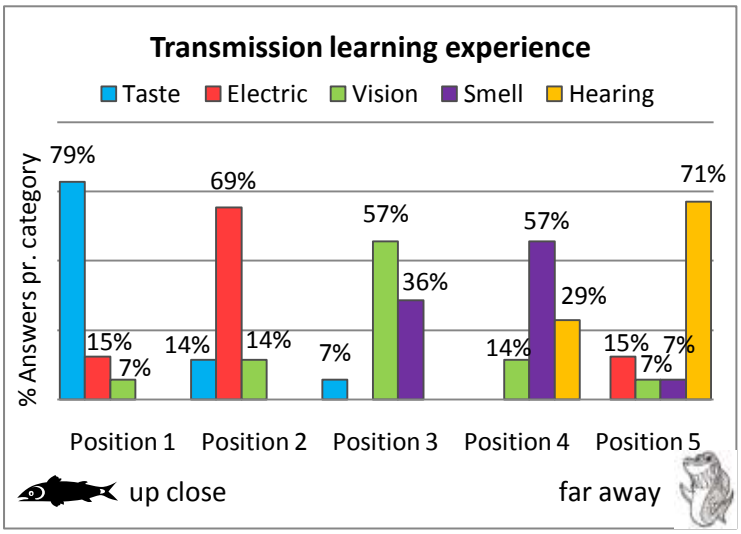
The following results are divided into groups of content, process and attitude questions.

4.3.1 Content questions Q1; Q2; Q7

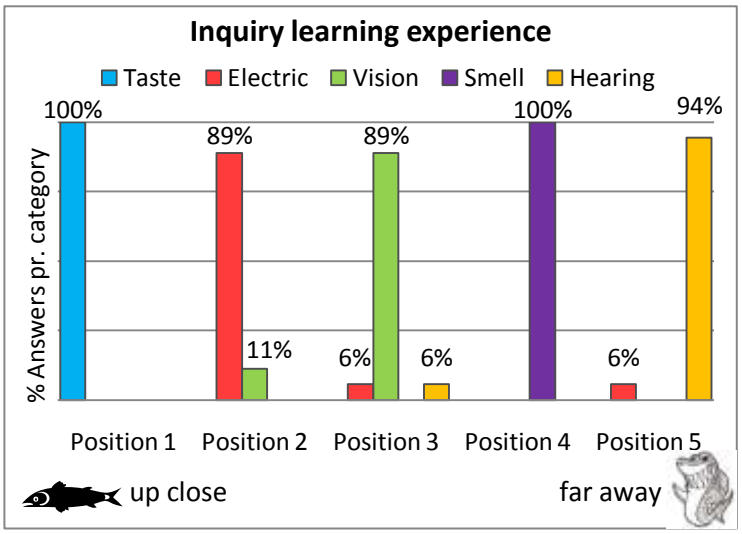
4.3.1.1 Question 1



Graph 3 and 4 show the results of the transmission and inquiry learning experience respectively. A quick glance at the two graphs unveils a striking difference in the answers between the two groups, the answers from the inquiry group looks much neater which means that they seem to agree more on where to place the senses than the transmission group. The transmission group seemed to agree most upon the senses closest to and furthest away from the fish, e.g. 79% placed taste in position 1, 71% placed hearing in position 5 and 69% agreed that the electric sense belong in position 2. There seems to be some confusion about the senses in position 3 and 4 where only 57% placed vision in 3 and smell in 4. The inquiry group was in complete agreement about the placement of taste in position 1 and smell in position 4 with a 100%, the agreement was a little less with the other 3 positions however 94% placed hearing in position 5, and 89% placed electric in position 2 and vision in position 3.



Graph 3: Placements of the senses by the transmission group. The bars indicate percentages of placements in each category.

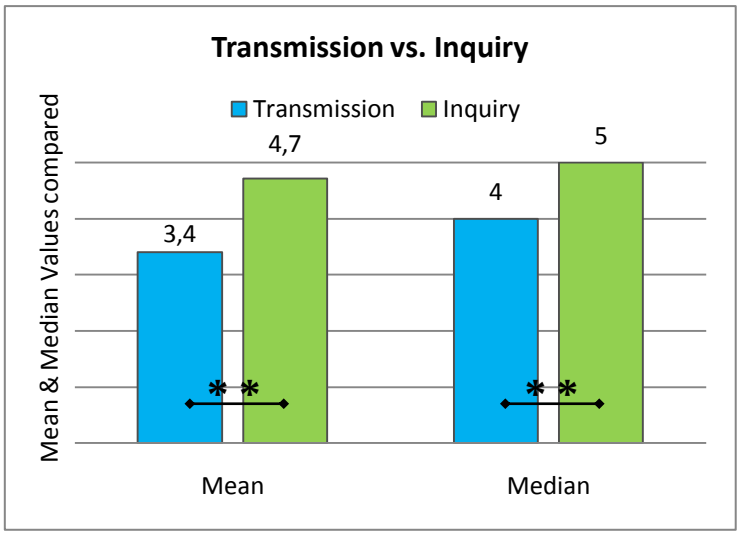


Graph 4: Placements of the senses by the transmission group. The bars indicate percentages of placements in each category.

Table 1 shows the scores of the individual questionnaires, depending on how many correct placements each questionnaire of transmission and inquiry. The Mann-Whitney U and the unpaired t-test reveals a very significant statistical difference with a P value < 0.001 between the medians and means (respectively) of the two groups. Graph 4 shows the means and medians of the data in table 1, and it clearly show that the inquiry group have higher scores than the transmission group.

Transmission		Inquiry	
Quest.	P	Quest.	P
6T	3	1	5
8T	5	2	5
9T	1	3	5
12T	4	4	5
13T	1	5	3
14T	5	6	5
15T	5	8	5
16T	1	12	5
18T	3	13	5
20T	5	14	5
21T	2	17	2
23T	1	18	5
27T	5	21	5
28T	5	23	5
30T	5	24	5
		25	5
		26	5
		27	5

Table 1: Scores of each questionnaire. (Mann-Whitney U = 75.5; P = 0.0086; unp. T-test = 2.834; P = 0.008**)**

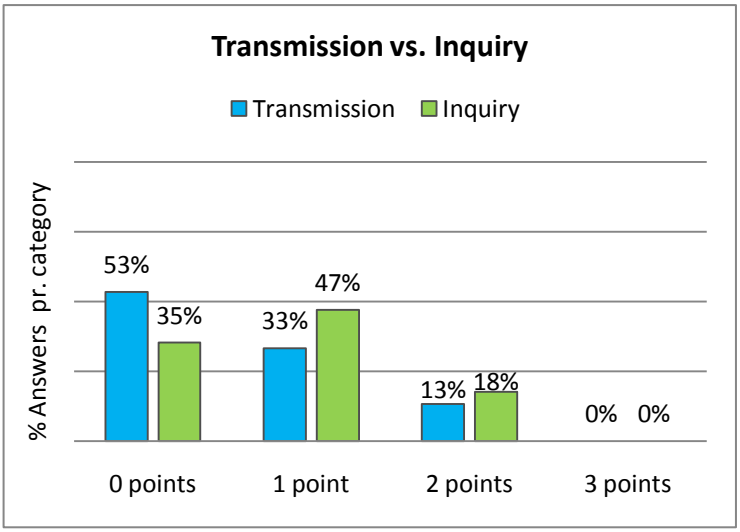


Graph 5: Comparison of the means and the medians of transmission and inquiry. (Mann-Whitney U = 75.5; P = 0.0086; unp. T-test = 2.834; P = 0.008**). Significance marked by **.**

4.3.1.2 Question 2

2. Hvorfor bruges sanserne **4** og **5** i spørgsmål 1 hovedsageligt på længere afstande?

Graph 6 shows the percentage of answers which received from 0 to 3 points. 53% of the transmission group received 0 points as opposed to only 35% of the inquiry. 47% of the inquiry group and 33% of the transmission received 1 point and only 18% and 13% of the inquiry and transmission



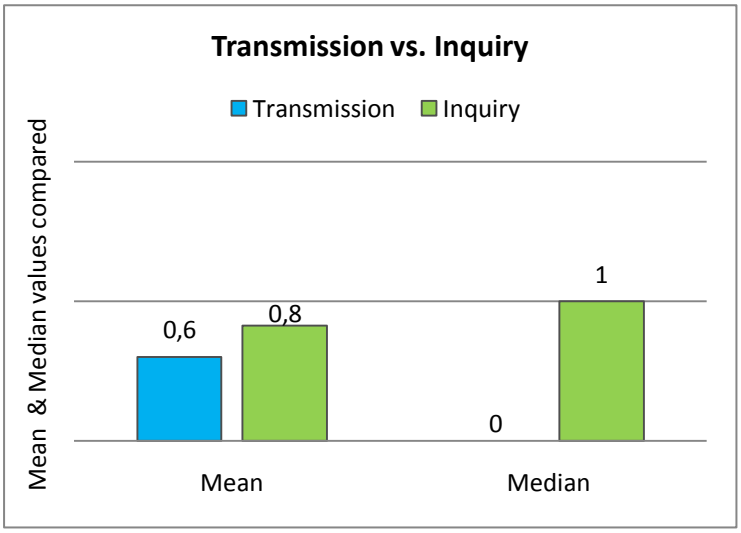
Graph 6: Percentages of answers given from 0 to 3 points

(respectively) received 2 points. None of them received 3 points.

Table 2 shows the number of points of each questionnaire received and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a significant difference. Graph 7 illustrate the mean and median of the point data from table 2, as you can see the inquiry group also has a greater mean and median albeit a much smaller difference than seen in Q2.

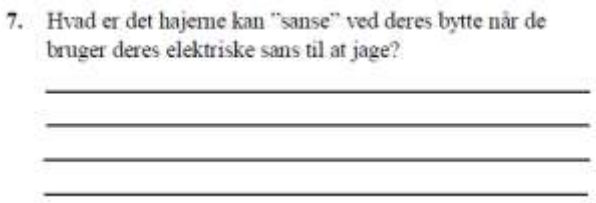
Transmission		Inquiry	
Quest.	P	Quest.	P
6T	0	1	0
8T	0	2	1
9T	0	3	0
12T	0	4	1
13T	1	6	0
14T	0	8	1
15T	1	12	1
16T	1	13	2
18T	0	14	1
20T	1	17	0
21T	1	18	1
23T	0	21	1
27T	2	23	2
28T	0	24	2
30T	2	25	0
		26	0
		27	1

Table 2: Scores of each questionnaire. (Mann-Whitney U = 105; P = 0.3665, ns; unp. T-test = 0.8621 P = 0.3955, ns)

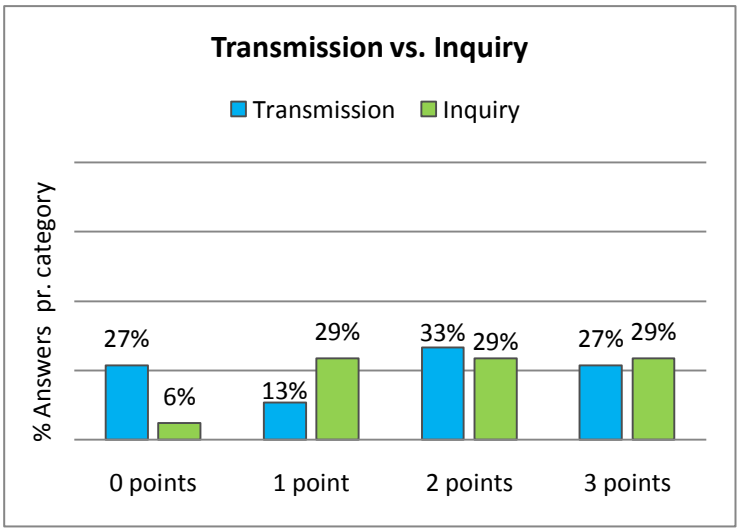


Graph 7: Comparison of the means and the medians of transmission and inquiry. (Mann-Whitney U = 105; P = 0.3665, ns; unp. T-test = 0.8621 P = 0.3955, ns)

4.3.1.3 Question 7


7. Hvad er det hajerne kan "sanse" ved deres bytte når de bruger deres elektriske sans til at jage?

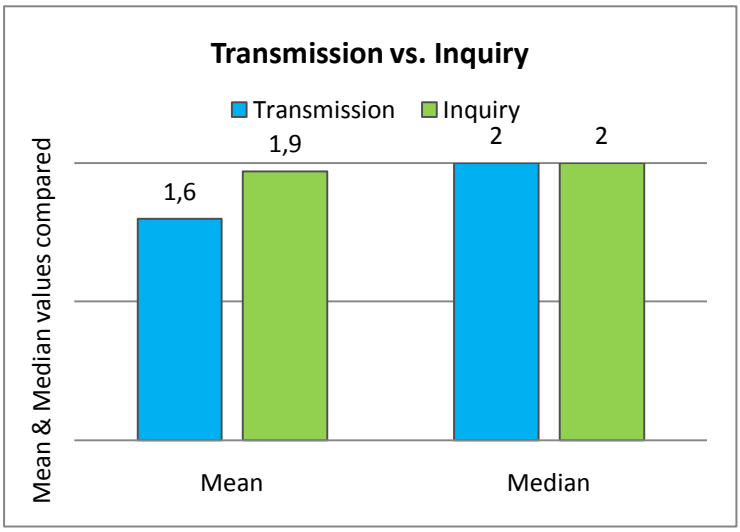
Graph 6 shows the percentage of answers which received from 0 to 3 points. 27% of the transmission group received 0 points as opposed to only 6% of the inquiry. 13% of the transmission group and 29 % of the inquiry received 1 point. When you look at how large



Graph 8: Percentages of answers given from 0 to 3 points

a percentage received 3 and 4 points the two group were almost equal with around 30% in each category.

Table 3 shows the number of points of each questionnaire received and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a significant difference. Graph 9 illustrate the mean and median of the point data from table 3, as you can see the inquiry group has a slightly higher mean value than the transmission group, the medians are the same.



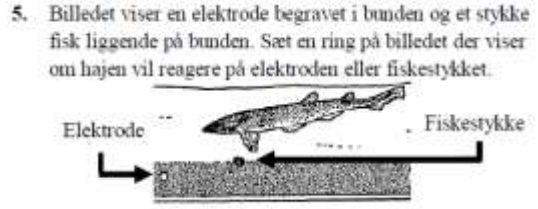
Graph 9: Comparison of the means and the medians of transmission and inquiry. (Mann-Whitney U = 107.5; P = 0.4440, ns; unp. T-test = 0.8976 P = 0.3766, ns)

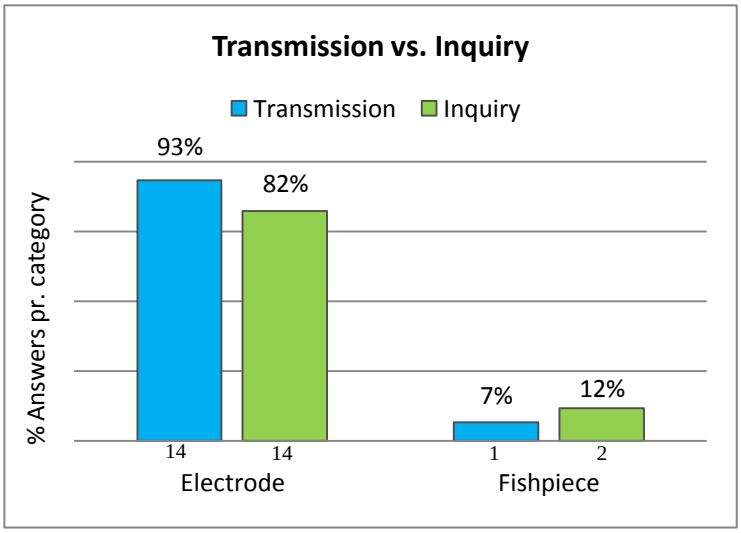
Transmission		Inquiry	
Quest.	P	Quest.	P
6T	0	1	2
8T	3	2	1
9T	1	3	1
12T	0	4	3
13T	2	6	3
14T	2	8	3
15T	2	12	1
16T	1	13	1
18T	0	14	2
20T	3	17	0
21T	2	18	3
23T	3	21	2
27T	2	23	3
28T	0	24	2
30T	3	25	2
		26	3
		27	1

Table 3: Scores of each questionnaire. (Mann-Whitney U = 107.5; P = 0.4440, ns; unp. T-test = 0.8976 P = 0.3766, ns)

4.3.2 Process questions Q5; Q6; Q8; Q9; Q10;Q11

4.3.2.1 Question 5

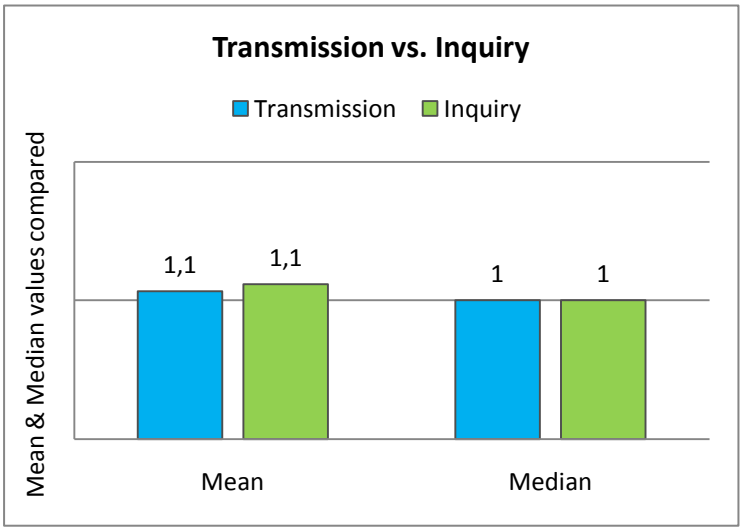




Graph 10: Percentages of answers of the two categories by transmission and inquiry groups. Bottom figures indicate the exact number of answers pr. category

Graph 10 show percentages and number of answers in each category by the two groups. 93% (14 answerers) of the transmission group have chosen the electrode over the fishpiece, the same number of answerers from the inquiry group have also chosen the electrode over the fishpiece, however since one inquiry answerer chose not to answer this question and 2 have chosen the fishpiece this corresponds to only 82%.

Table 4 shows the scores each questionnaire and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a significant difference. Graph 11 illustrates the mean and median of the point data from table 4, as you can see the means and the medians are the same.



Graph 11: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 113, P = 0.616, ns; unp. T-test = 0.5336, P = 0.5977, ns)

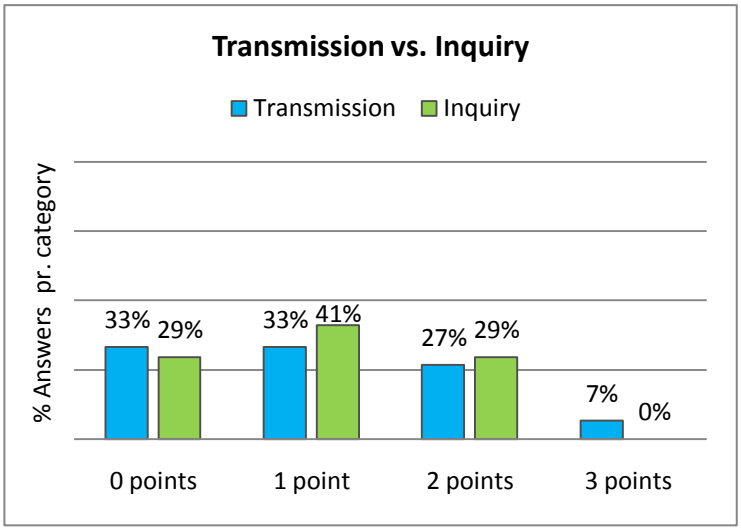
Transmission		Inquiry	
Quest.	P	Quest.	P
6T	1	1	
8T	1	2	1
9T	2	3	1
12T	1	4	1
13T	1	5	1
14T	1	6	1
15T	1	8	1
16T	1	12	1
18T	1	13	1
20T	1	14	1
21T	1	17	2
23T	1	18	1
27T	1	21	1
28T	1	23	1
30T	1	24	2
		25	1
		26	1
		27	1

Table 4: Scores of each questionnaire. (Mann-Whitney U = 113, P = 0.616, ns; unp. T-test = 0.5336, P = 0.5977, ns)

4.3.2.2 Question 6

6. Forklar hvorfor hajen vælger at reagere på elektroden eller fiskestykket i spørgsmål 5.

Graph 12 show percentages of answers in each category by the two groups. Within the two group there is an almost equal percentage of answerers who receive 1 point, e.g. 33% of the transmission and 29% of the inquiry. 33% of the transmission group and 41% of the inquiry received 1 point and 27% and 29% respectively received 2 points. Only 7 % of the transmission received 3 points however none of the inquiry answerers received 3 points.

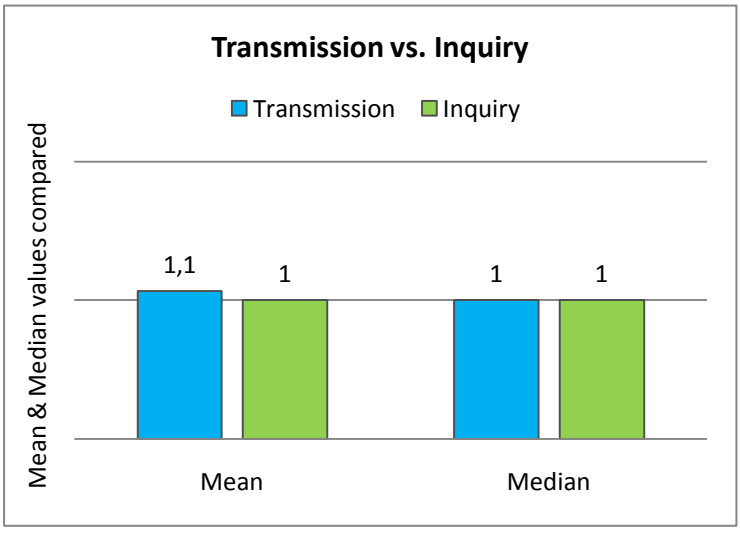


Graph 12: Percentages of answers given from 0 to 3 points

Table 5 shows the scores of each questionnaire and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a significant difference. Graph 13 illustrates the mean and median of the point data from table 5, as you can see the transmission group has a slightly higher mean value than the inquiry group, the medians are the same.

Transmission		Inquiry	
Quest.	P	Quest.	P
6T	1	1	0
8T	3	2	2
9T	0	3	1
12T	0	4	2
13T	2	6	0
14T	1	8	0
15T	0	12	1
16T	1	13	1
18T	1	14	1
20T	2	17	0
21T	2	18	1
23T	0	21	1
27T	1	23	2
28T	0	24	0
30T	2	25	1
		26	2
		27	2

Table 5: Scores of each questionnaire. (Mann-Whitney U = 125, P = 0.9364, ns; unp. T-test = 0.2152, P = 0.831, ns)



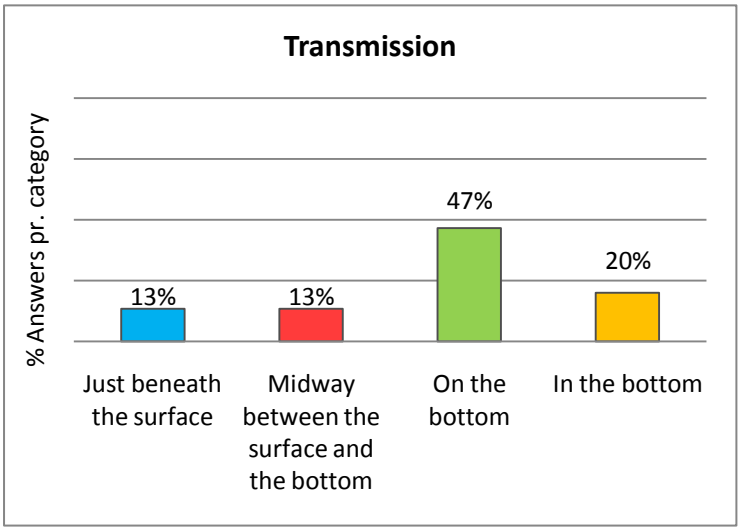
Graph 13: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 125, P = 0.9364, ns; unp. T-test = 0.2152, P = 0.831, ns)

4.3.2.3 Question 8

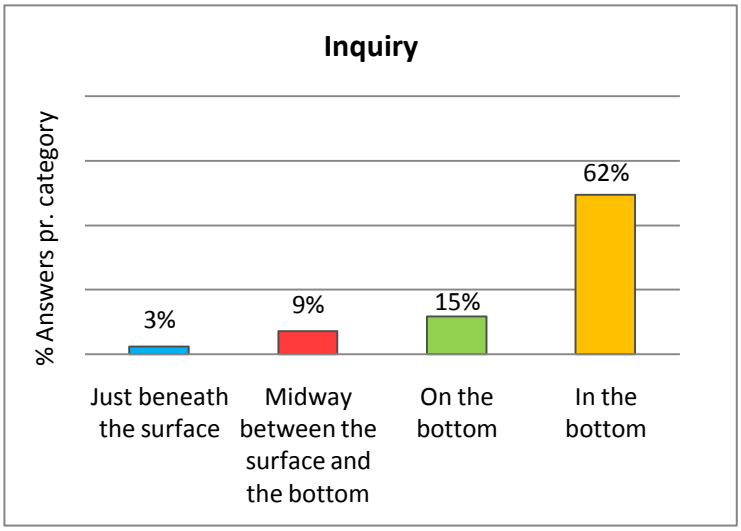
8. Hvilke hajer har størst brug af deres elektriske sans? Dem hvis byttedyr lever…

- ☐ Lige under havets overflade
- ☐ Midtvejs mellem overfladen og havets bund
- ☐ På bunden af havet
- ☐ I havbunden

Figure 14 and 15 illustrate how large a percentage of answers each of the four categories have received from the two groups (transmission and inquiry). The most striking difference between the answers of the two groups is that 47% of the transmission group (15% of the inquiry group) agrees that the sharks which have the most use of their electric sense are sharks hunting ON the bottom where 62% of the inquiry group (20% of the transmission group) agree that it is sharks hunting IN the bottom. 13% of the transmission and only 3% of the inquiry group agree that it is sharks hunting just beneath the surface, and 13% transmission and 9% inquiry agree that it is sharks hunting midway between the surface and the bottom.

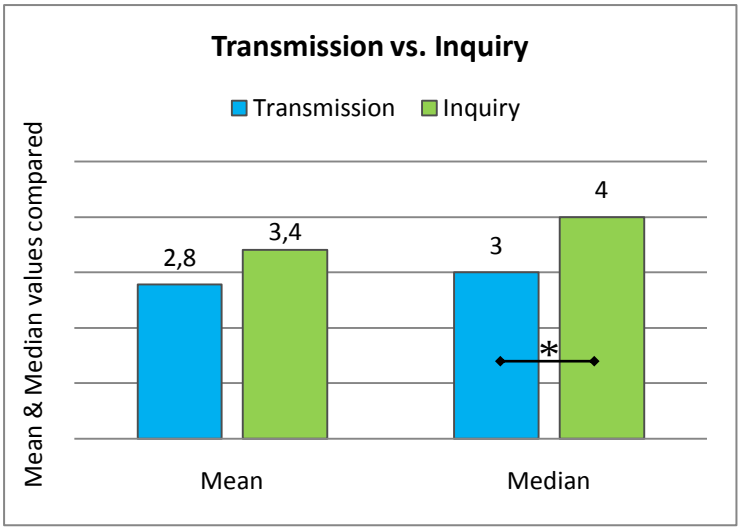


Graph 14: Percentages of answers of the four categories by the transmission group.



Graph 15: Percentages of answers of the four categories by the inquiry group.

Table 6 shows the scores of each questionnaire and that the Mann-Whitney U test for difference in the medians reveals significant difference with $p < 0.05$. The unpaired t-test for difference in means is close to significance, but not quite with $p = 0.0798$. If I had removed the inquiry questionnaires with two answers I would have gotten a very significant difference between both the medians (Mann-Whitney U = 39; P = 0.0067**) and the means (unpaired t-test = 2,844; P = 0.0088**). Graph 16 illustrates the mean and median of the point data from table 6, as you can see the inquiry group has a much higher mean value and a higher median than the transmission group



Graph 16: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 71, P = 0.0435*; unp. T-test = 1.816, P = 0.0798, ns). Significance marked by *.

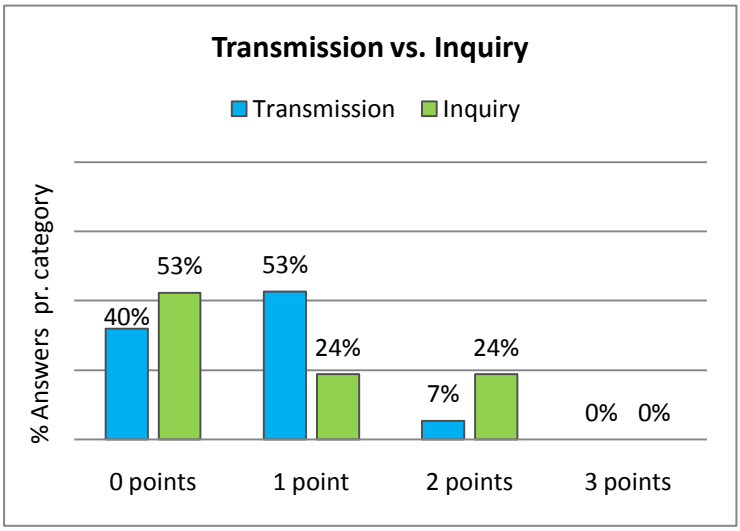
Transmission		Inquiry	
Quest.	P	Quest.	P
6T	1	1	
8T	2	2	4
9T	3	3	4
12T	2	4	4
13T	3	6	
14T	3	8	3+4
15T	1	12	4
16T	3	13	1+2
18T	3	14	4
20T	4	17	3
21T	3	18	4
23T		21	2
27T	3	23	4
28T	4	24	4
30T	4	25	3
		26	4
		27	4

Table 6: Scores of each questionnaire. (Mann-Whitney U = 71, P = 0.0435*; unp. T-test = 1.816, P = 0.0798, ns)

4.3.2.4 Question 9

9. Forklar hvorfor den elektriske sans er mere brugbar for den type haj du har valgt i det foregående spørgsmål?

Graph 17 shows the percentages of answers in each category by the two groups. In this question quite a few more of the inquiry (53%) than the transmission (40%) answers received 0 points, and 53% of the transmission answers vs. 24% of inquiry received 1 point. However, only 7% of the transmission answers got 2 points where 24% of the inquiry answers achieved this score. None of the groups answers received 3 points.

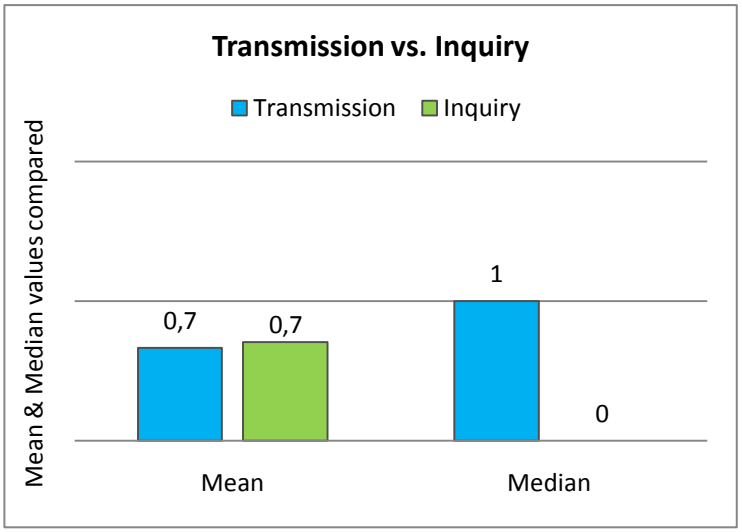


Graph 17: Percentages of answers given from 0 to 3 points

Transmission		Inquiry	
Quest.	P	Quest.	P
6T	0	1	0
8T	1	2	1
9T	0	3	2
12T	0	4	0
13T	0	6	0
14T	1	8	1
15T	0	12	0
16T	1	13	0
18T	1	14	0
20T	2	17	1
21T	1	18	2
23T	0	21	0
27T	1	23	1
28T	1	24	2
30T	1	25	0
		26	0
		27	1

Table 7: Scores of each questionnaire. (Mann-Whitney U = 118, P = 0.9486, ns; unp. T-test = 0.3090, P = 0.7596, ns)

Table 7 shows the number of points of each questionnaire received and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a significant difference. Graph 18 illustrate the mean and median of the point data from table 7, as you can see the transmission group has a slightly higher mean value than the inquiry group, the medians are the same



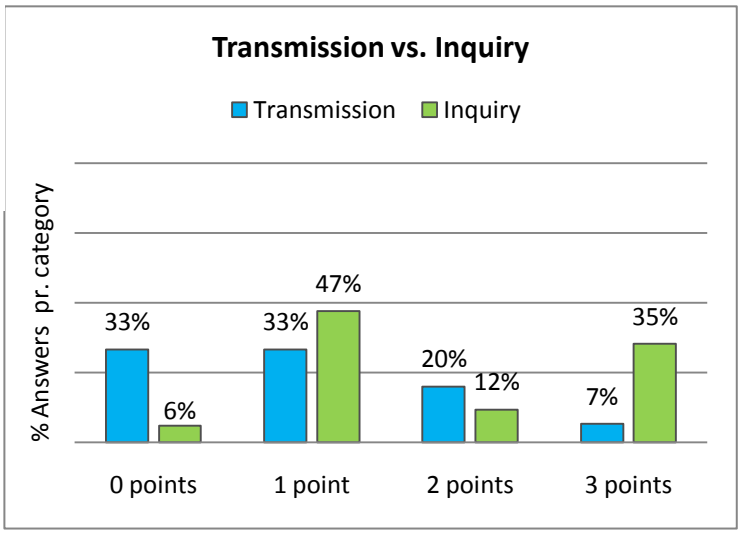
Graph 18: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 118, P = 0.9486, ns; unp. T-test = 0.3090, P = 0.7596, ns)

4.3.2.5 Question 10

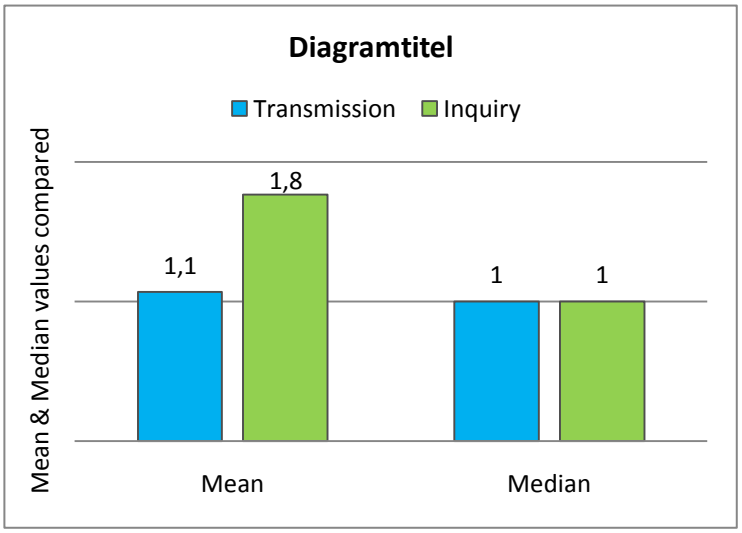
10. Forklar hvorfor det er vigtigt at være rolig og afslappet når man er i vandet med en haj?

Graph 19 shows the percentages of answers in each category by the two groups. In this question quite a few more of the transmission (33%) than the inquiry (6%) answers received 0 points, and 33% of the transmission answers vs. 47% of inquiry received 1 point. However, only 12% of the inquiry answers got 2 points where 20% of the transmission answers achieved this score. 7 % of the transmission answers and 35% of the inquiry answers received 3 points.

Table 8 shows the scores each questionnaire and that neither the Mann-Whitney U test for difference in the medians nor the unpaired t-test for difference in means found a



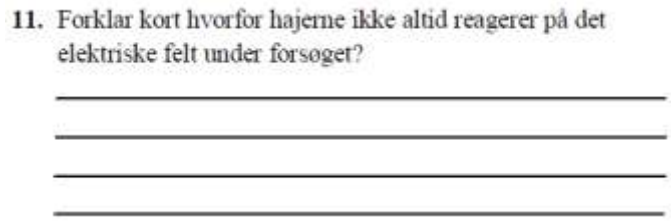
Graph 19: Percentages of answers given from 0 to 3 points



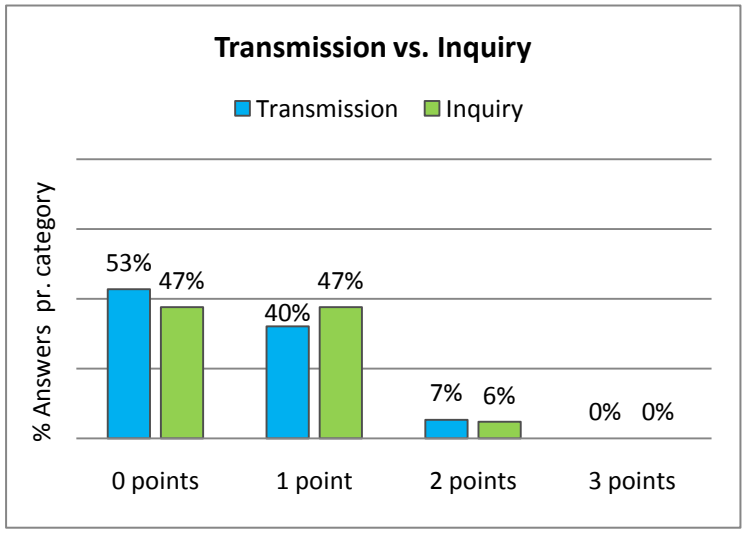
Graph 20: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 81.5, P = 0.0717, ns; unp. T-test = 1.971. P = 0.058, ns)

significant difference. However both p-values are fairly close the significance value (Mann-Whitney U = 81.5; P = 0.0717, ns; unp. T-test = 1.971. P = 0.058, ns). Graph 18 illustrates the mean and median of the point data from table 8, as you can see the inquiry group has a higher mean value than the transmission group, the medians are the same.

4.3.2.6 Question 11


11. Forklar kort hvorfor hajerne ikke altid reagerer på det elektriske felt under forsøget?

Graph 21 shows the percentages of answers in each category by the two groups. A few more of the transmission (53%) than the inquiry (47%) answers received 0 points, and 40% of the transmission answers vs. 47% of inquiry received 1 point. Only 7% of the transmission group and 6 % of the inquiry group received 2 points and none of the groups received 3 points.



Graph 21: Percentages of answers given from 0 to 3 points

Table 9 shows the number of points of each questionnaire received and that neither the Mann-Whitney U test for difference in the

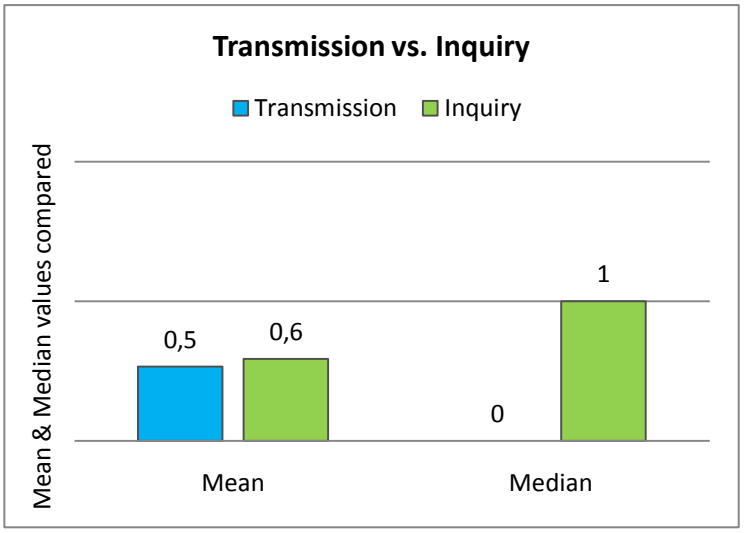
Transmission		Inquiry	
Quest.	P	Quest.	P
6T	0	1	0
8T	1	2	3
9T	0	3	1
12T	2	4	3
13T	1	6	1
14T	0	8	3
15T	0	12	2
16T	3	13	1
18T	0	14	3
20T	2	17	1
21T	1	18	3
23T	2	21	1
27T	2	23	1
28T	1	24	3
30T	1	25	1
		26	1
		27	2

Table 8: Scores of each questionnaire. (Mann-Whitney U = 81.5, P = 0.0717, ns; unp. T-test = 1.971. P = 0.058, ns)

Transmission		Inquiry	
Quest.	P	Quest.	P
6T	0	1	0
8T	0	2	0
9T	0	3	0
12T	1	4	0
13T	1	6	0
14T	0	8	1
15T	1	12	0
16T	1	13	1
18T	1	14	1
20T	1	17	1
21T	0	18	1
23T	0	21	0
27T	0	23	1
28T	0	24	1
30T	2	25	2
		26	0
		27	1

Table 9: Scores of each questionnaire. (Mann-Whitney U = 120.5, P = 0.7827, ns; unp. T-test = 0.2466. P = 0.8069, ns)

medians nor the unpaired t-test for difference in means found a significant difference. Graph 22 illustrates the mean and median of the point data from table 9, as you can see the inquiry group has a slightly higher mean value than the transmission group, and the median is also higher.



Graph 22: Comparison of the means and the medians of the transmission and inquiry group. (Mann-Whitney U = 120.5, P = 0.7827, ns; unp. T-test = 0.2466. P = 0.8069, ns)

4.3.3 Attitude questions: Q3; Q4; Q12-Q16

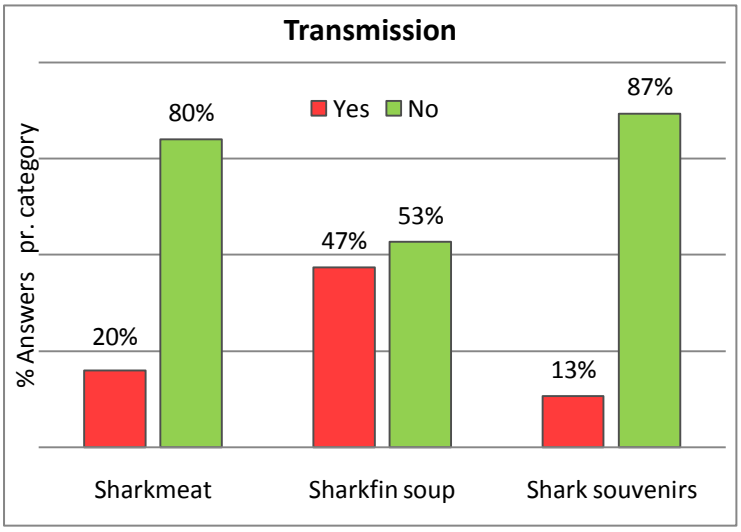
4.3.3.1 Question 3 & 4

3. Har du spist hajkod eller hajfinne suppe?
   Haj kod Ja Nej
   Haj finne suppe Ja Nej

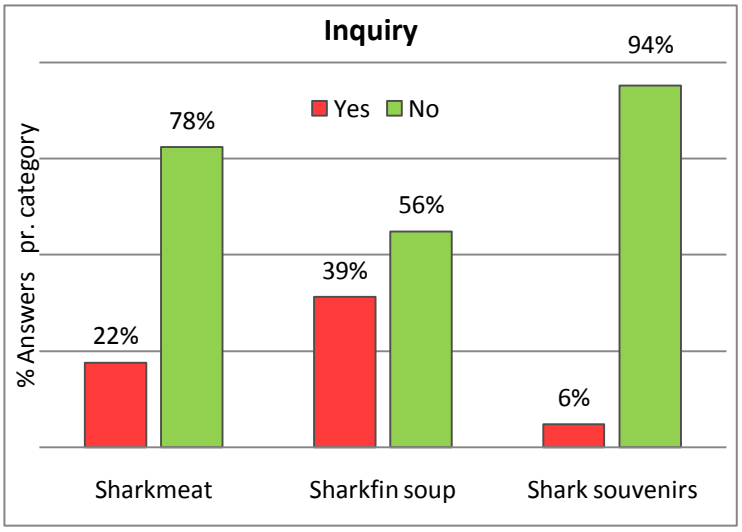
4. Har du nogensinde købt haj souvenirs (tænder, kæber, finner el.lign.)? Ja Nej

Graph 23 and 24 show how large a percentage answer yes or no to questions about whether or not they have consumed or bought shark items. In general both the transmission and the inquiry group do not have too much experience with eating sharkmeat and neither of the groups have bought that many shark souvenirs. It is a different matter for the sharkfin soup where approximately 40% in both groups have eaten it. As seen below there is no significant difference in neither the means nor the medians of the answers about sharkmeat, sharkfin soup and shark souvenirs between inquiry and transmission.

- Sharkmeat: (Mann-Whitney U=132, P=0.8985, ns; unp. T-test = 0.1508. P = 0.8811, ns)
- Sharkfin soup (Mann-Whitney U=120.5, P=0.7752, ns; unp. T-test = 0.3030. P = 0.764, ns)
- Sharkfin souvenirs (Mann-Whitney U=124.5, P=0.468, ns; unp. T-test = 0.7570. P = 0.4548, ns)

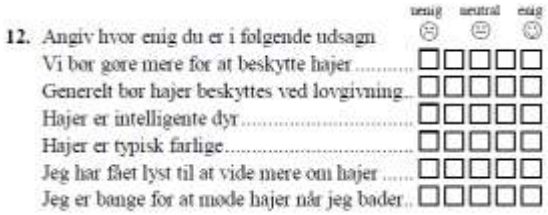


Graph 23: Percentages of yes and no answers in the three categories by the transmission group.



Graph 24: Percentages of yes and no answers in the three categories by the inquiry group.

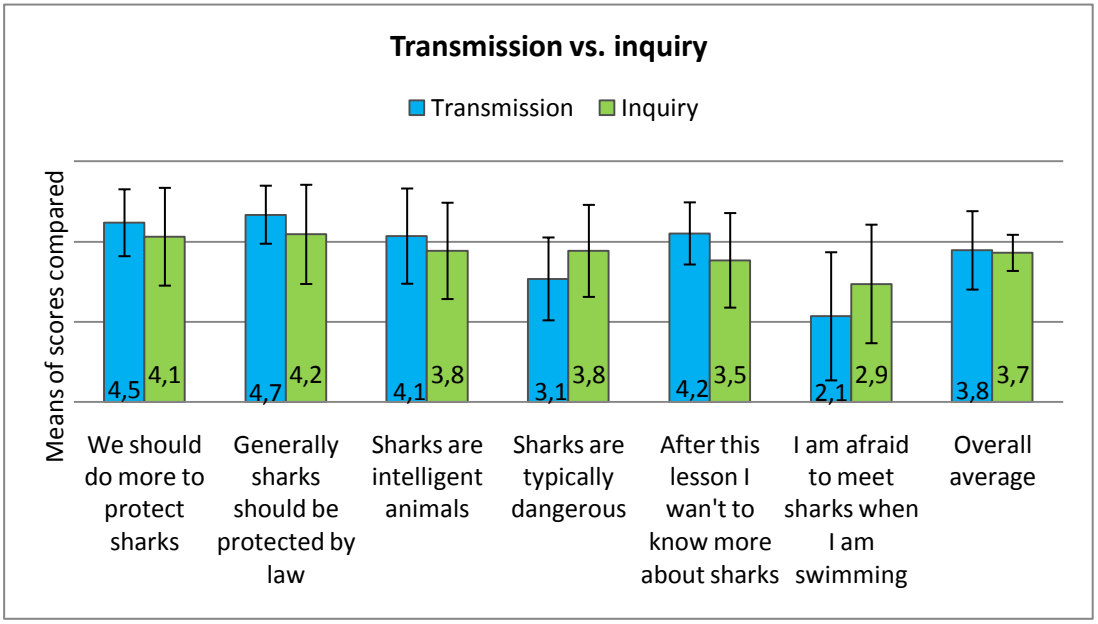
4.3.3.2 Question 12



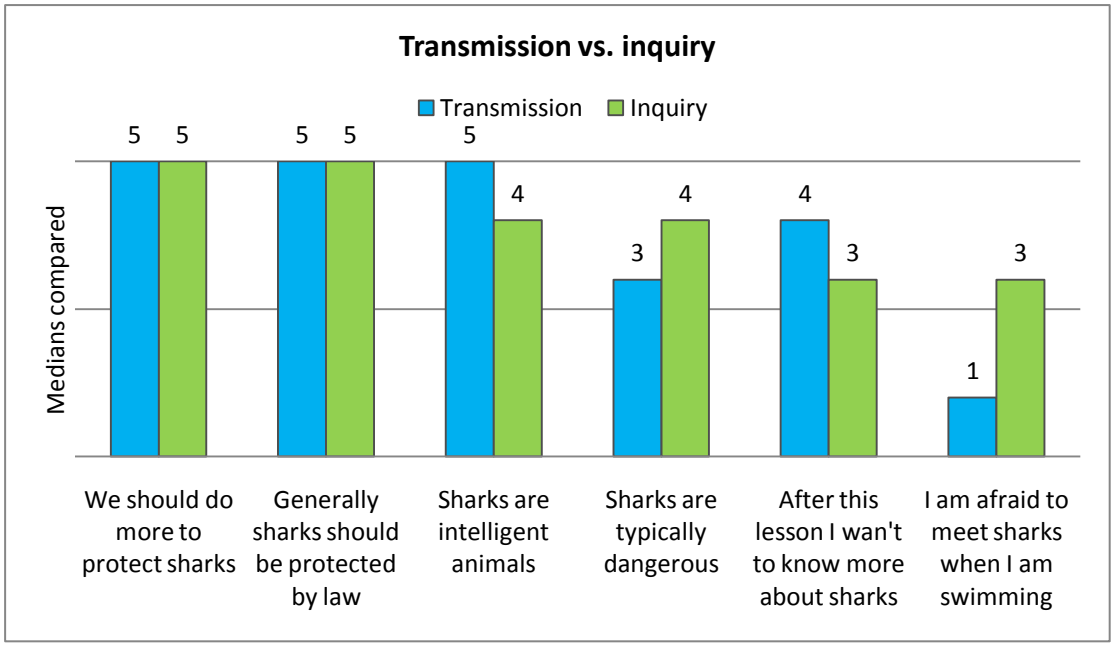
Graph 25 shows a comparison of the mean of the scores each questionnaire received. If we break it down into sections we can see that the transmission group has a slight tendency to say that "we should do more to protect sharks", "That sharks should be protected by law" and that "sharks are intelligent animals" however as you can on graph 26 the medians are the same (except for a smaller median for inquiry group in the question about sharks intelligence) and table 10 also show that the difference is not statically different.

When we analyze the statements "sharks are typically dangerous" and "I am afraid to meet sharks when I am swimming" we have to remember that they are reversed, so a high value here actually means that the answerer disagrees with the statement. The inquiry group has higher means and medians for these statements so therefore they are not as afraid to meet sharks while swimming and they also think sharks are less of a threat than the transmission group. There is no significal difference between transmission and inquiry for these statements either, however the medians (Mann-Whitney U = 84.50, P = 0.0974) and the means (unp. t-test = 1.799, P = 0.0821) are almost significantly different for the statement "sharks are typically dangerous".

The transmission group seems to be a little more keen on learning more about sharks than the inquiry group, and this difference is also close to being statistically significant for both medians (Mann-Whitney U = 84, P = 0.0877) and means (unp. t-test = 1.873, P = 0.0708).



Graph 25: Compared means of the scores of each questionnaire.



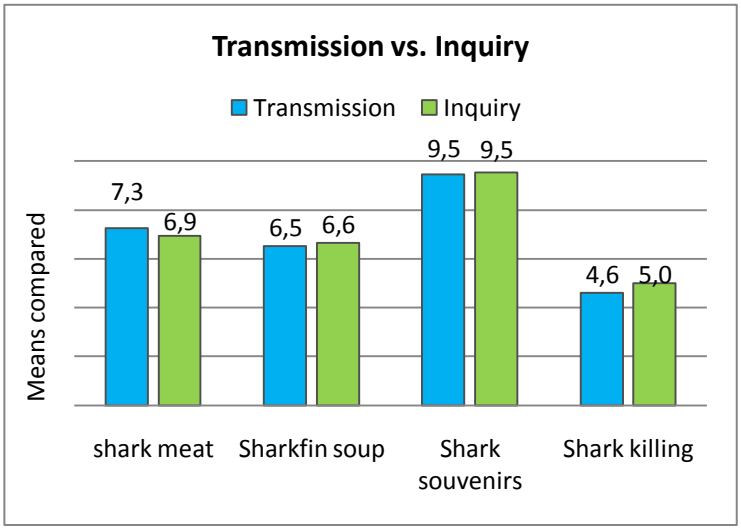
Graph 26: Compared medians of the scores of each questionnaire.

Statement:	Mann-Whitney U	Unp. t-test
We should do more to protect sharks	U = 109; P = 0.4418, ns	t = 0.9324; P = 0.3586, ns
Generally sharks should be protected by law	U = 99.5; P = 0.2051, ns	t = 1.344; P = 0.1890, ns
Sharks are intelligent animals	U = 102; P = 0.3172, ns	t = 0.8713; P = 0.3905, ns
Sharks are typically dangerous	U = 84.50; P = 0.0974, ns	t = 1.799; P = 0.0821, ns
After this lesson I want to know more about sharks	U = 84; P = 0.0877, ns	t = 1.873; P = 0.0708, ns
I am afraid to meet sharks when I am swimming	U = 88.50; P = 0.2153, ns	t = 1.206; P = 0.2377, ns

Table 10: Results of the Mann-Whitney and the unpaired- t-test for each statement.

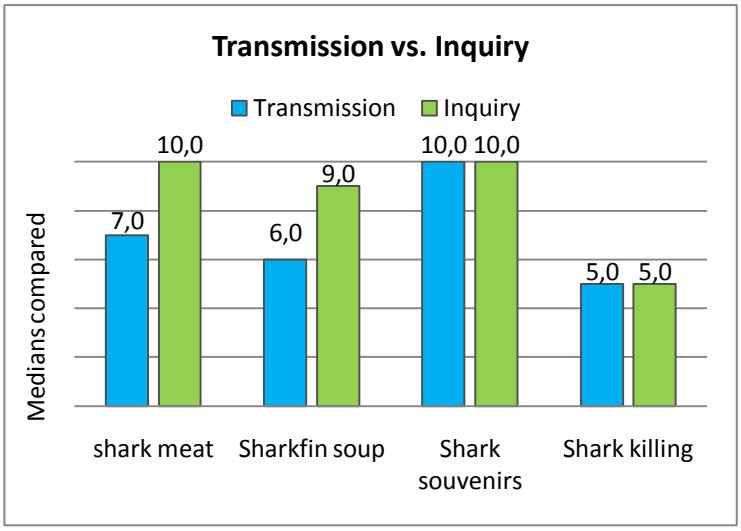
4.3.3.3 Question 13, 14 & 15

In general there is no a discernable difference between any of the means



Graph 27: Compared means of the scores of each questionnaire.

between the answers of the transmission and the inquiry group (graph 27) and the unpaired t-test couldn't find a difference either (table 11). Graph 28 illustrates the difference between the medians and it reveals a slightly greater difference than the means, however as seen in table 11 this difference is by no means significant. In the first three categories of graph 28, a higher median shows a shift towards "saying no" to buying or eating shark items, and the inquiry group seems less inclined to eat shark items. The category "shark killing" is a measure of how endangered the audiences think sharks are, however there was no difference between the answers of the transmission and the inquiry group (graph 27 & 28; table 11).

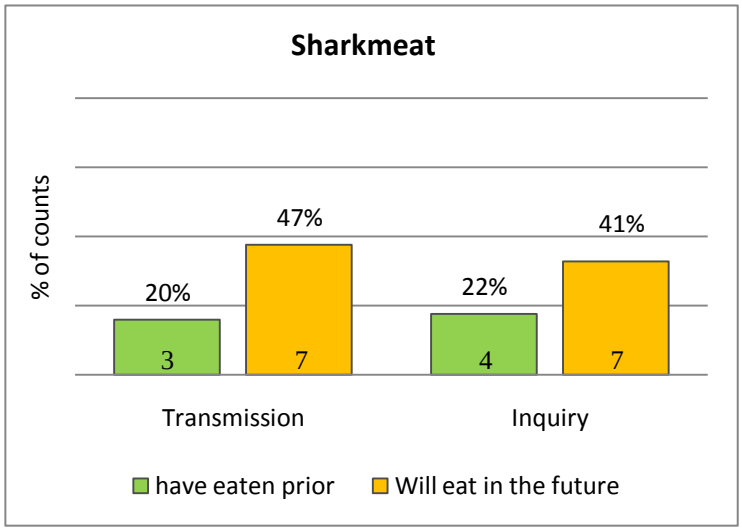


Graph 28: Compared medians of the scores of each questionnaire.

Statement:	Mann-Whitney U	Unp. t-test
Sharkmeat	U = 119.5; P = 0.7605, ns	t = 0.2754; P = 0.7849, ns
Sharkfin soup	U = 126.5; P = 0.9842, ns	t = 0.09097; P = 0.9281, ns
Shark souvenirs	U = 124.5; P = 0.8897, ns	t = 0.1401; P = 0.8895, ns
"Shark killing"	U = 115.5; P = 0.6605, ns	t = 0.3622; P = 0.7198, ns

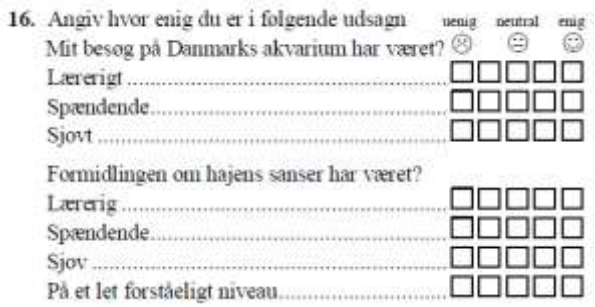
Table 11: Results of the Mann-Whitney and the unpaired- t-test for each question.

The graphs 29-31 are a comparison of the results from question 3+4 (have eaten/bought prior) and question 13+14 (will eat/buy in the future) and they illustrate the difference between how large a percentage have eaten/bought shark items in the past and how many are considering eating or buying in the future. Graph 29 shows that around 20% of both the transmission and the inquiry group have eaten shark meat in the past, however more than 40% of both groups consider eating shark meat in the future. Graph 30 reveals that there is no difference between how large a percentage had

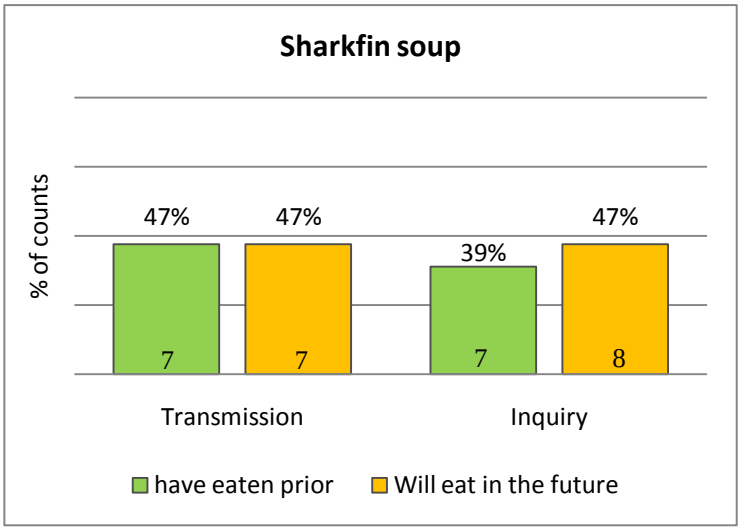


Graph 29: Comparing how many have eaten with how many will eat sharkmeat in the future between the transmission and the inquiry group. Bottom number show actual counts.

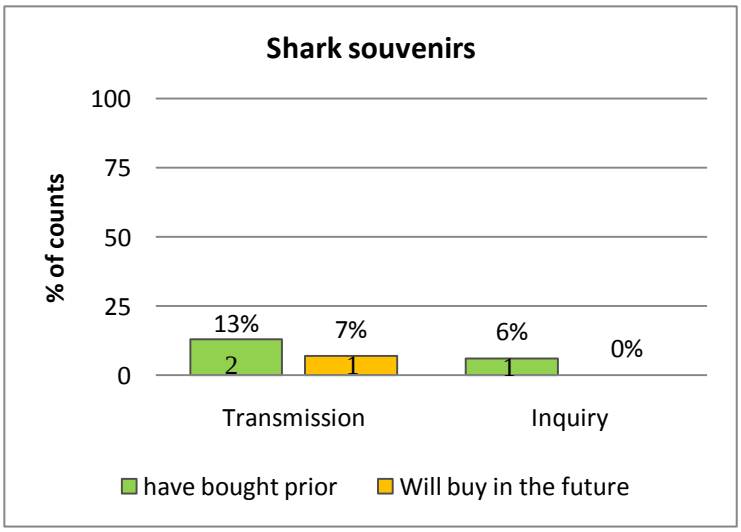
eaten sharkfin soup and how large a percentage will eat it in the future within the transmission group, however a slightly greater percentage would consider eating sharkfin soup within in inquiry group in the future. Graph 31 show a decline in willingness to buy shark souvenirs in the future compared to how many have bought in the past. This decline is percentage wise greater for the inquiry group than the transmission group, however if you look at the actual numbers there is a decline by 1 for both groups.


16. Angiv hvor enig du er i følgende udsagn — uenig, neutral, enig
Mit besøg på Danmarks akvarium har været?
Lærerigt
Spændende
Sjovt
Formidlingen om hajens sanser har været?
Lærerig
Spændende
Sjov
På et let forståeligt niveau

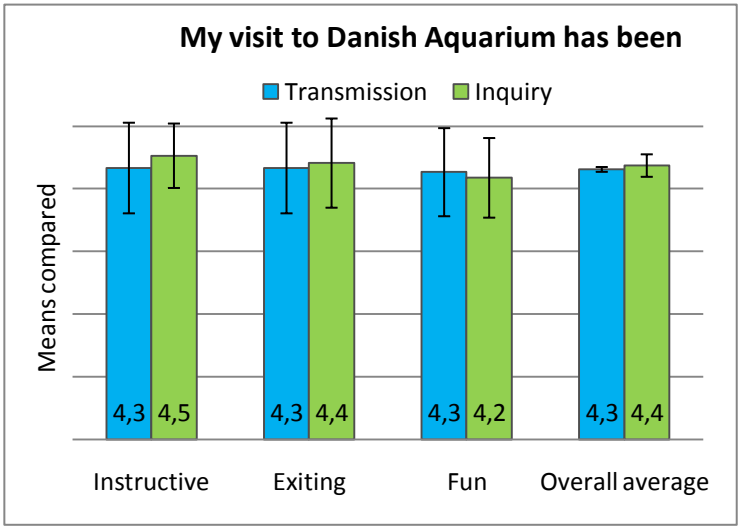
The first part of question 16 is about the participants experience at the Danish aquarium, in general there isn't any discernable difference between the means of the two groups (graph 32) and the unpaired t-test confirms this (table 12). The inquiry group has a slightly higher median (though not significant; table 12) than the transmission group regarding the statements "instructive"



Graph 30: Comparing how many have eaten with how many will eat sharkfin soup in the future between the transmission and the inquiry group. Bottom number show actual counts.



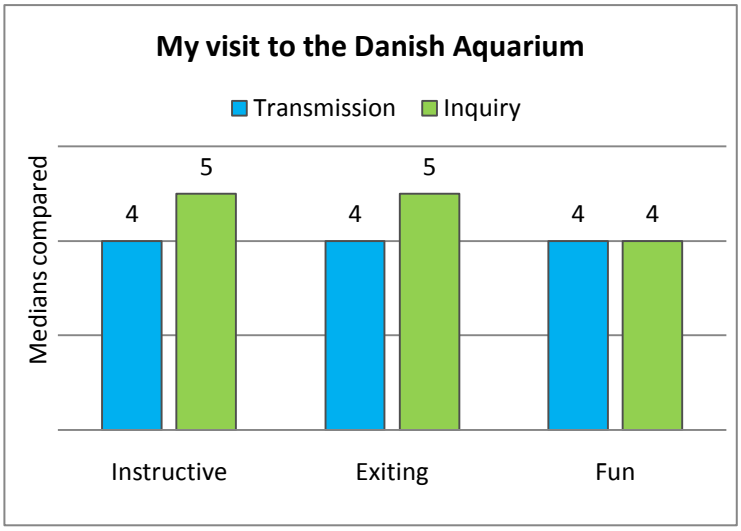
Graph 31: Comparing how many have bought with how many will buy shark souvenirs in the future between the transmission and the inquiry group. Bottom number show actual counts.



Graph 32: Compared means of the scores of each questionnaire.

and "exiting" but the medians for the statement "fun" are the same for the two groups (graph 33).

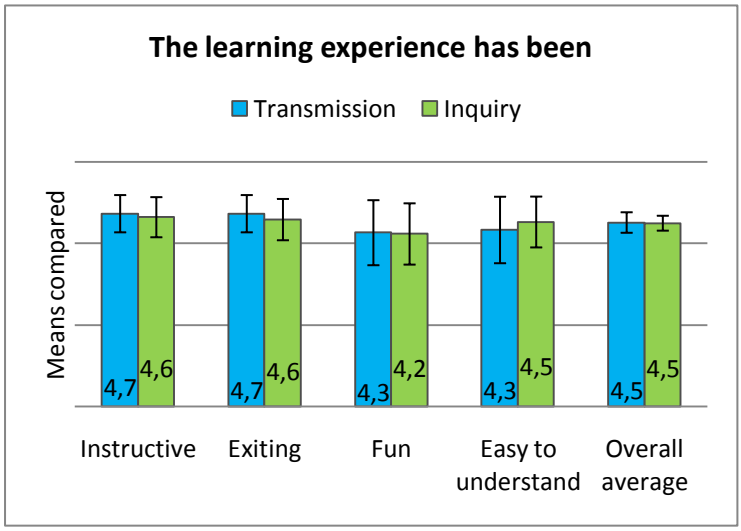
The second part of question 16 is about my learning experience, in general, again, there isn't any discernable difference between the means of the two groups (graph 34) and the unpaired t-test confirms this (table 13). The inquiry and the transmission group have the same medians for all statements (graph 35) and as expected there is no statistical difference between them (table 13)



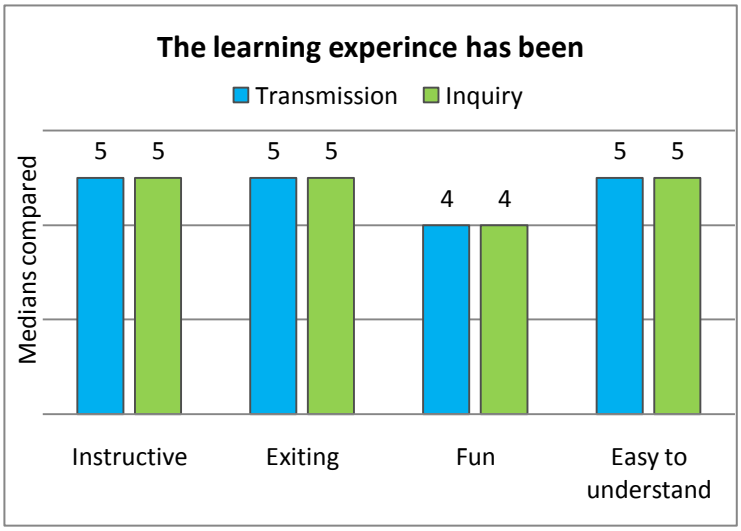
Graph 33: Compared medians of the scores of each questionnaire.

My visit to the Danish Aquarium:	Mann-Whitney U	Unp. t-test
Instructive	U = 111.5; P = 0.5107, ns	t = 0.8913; P = 0.3798, ns
Exiting	U = 119.5; P = 0.7546, ns	t = 0.3085; P = 0.7598, ns
Fun	U = 117; P = 0.6745, ns	t = 0.3809; P = 0.7060, ns

Table 12: Results of the Mann-Whitney and the unpaired- t-test for each question.



Graph 34 Compared means of the scores of each questionnaire.



Graph 35: Compared medians of the scores of each questionnaire.

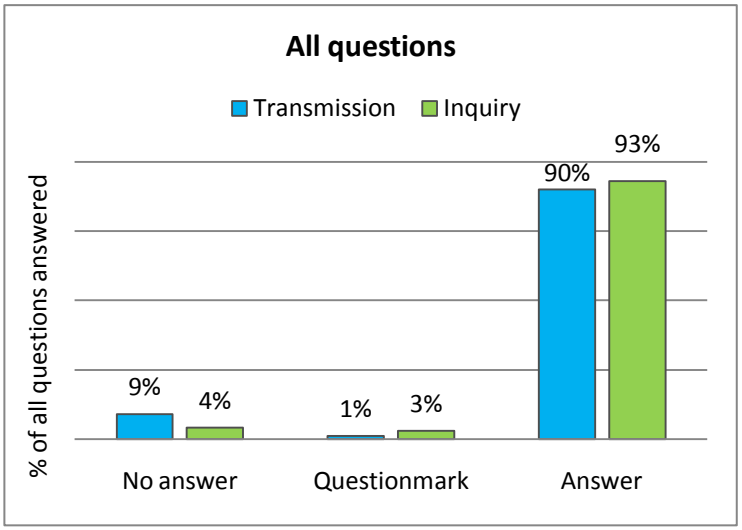
The learning experience:	Mann-Whitney U	Unp. t-test
Instructive	U = 116.5; P = 0.6216, ns	t = 0.5110; P = 0.6131, ns
Exiting	U = 109; P = 0.4089, ns	t = 0.8449; P = 0.4049, ns
Fun	U = 124; P = 0.9010, ns	t = 0.1444; P = 0.9097, ns
Easy to understand	U = 113.5; P = 0.5663, ns	t = 0.7684; P = 0.4483, ns

Table 13: Results of the Mann-Whitney and the unpaired- t-test for each question.

4.3.4 General analysis of the questionnaires

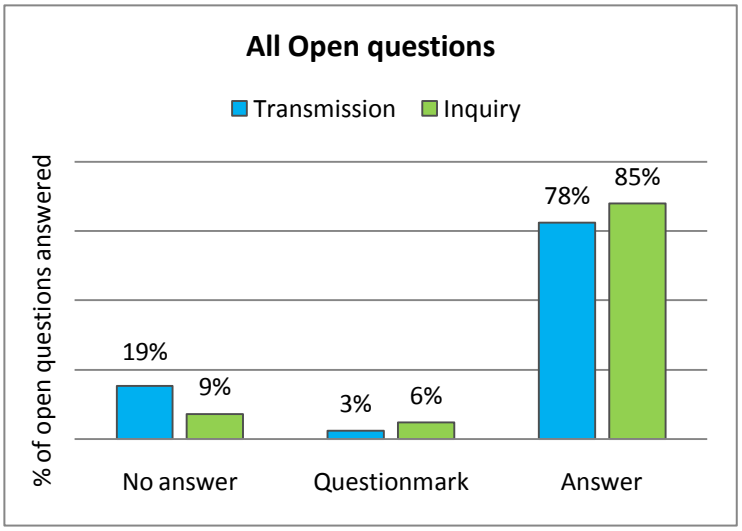
4.3.4.1 How many answered all questions, all open and all closed questions?

As you can see on graph 36, 9% of the questions of the transmission group were not answered, compared to only 4% of the inquiry groups. 1% and 3% of the transmission and the inquiry groups' questions (respectively) have been answered with a question mark. 90% transmission groups and 93% of the inquiry groups' questions have been answered.



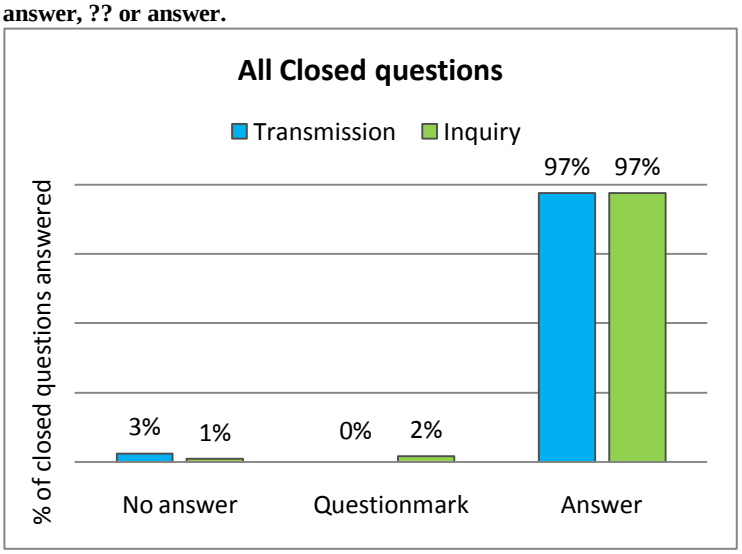
Graph 36: Pecentages who answered all question divided by: No answer, ?? or answer.

As you can see on graph 37, 19% of the open questions of the transmission group were not answered, compared to only 9% of the inquiry groups. 3% and 6% of the transmission and the inquiry groups' open questions (respectively) have been answered with a question mark. 78% transmission groups and 85% of the inquiry groups' open questions have been answered.



Graph 37: Pecentages who answered all open question divided by: No answer, ?? or answer.

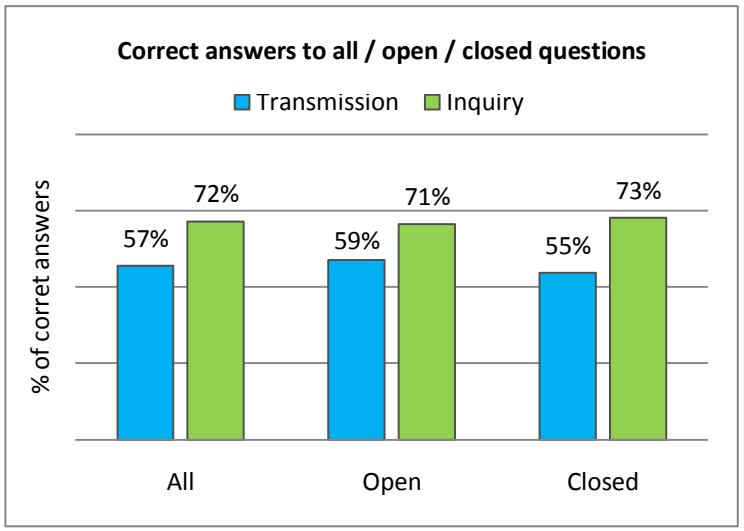
As you can see on graph 38, 3% and 1% of the closed questions of the transmission and the inquiry groups (respectively) were not answered. 0% and 2% of the transmission and the inquiry groups' open questions (respectively) have been answered with a question mark and 97% of the closed questions for both groups have been answered.



Graph 38: Pecentages who answered all closed question divided by: No answer, ?? or answer.

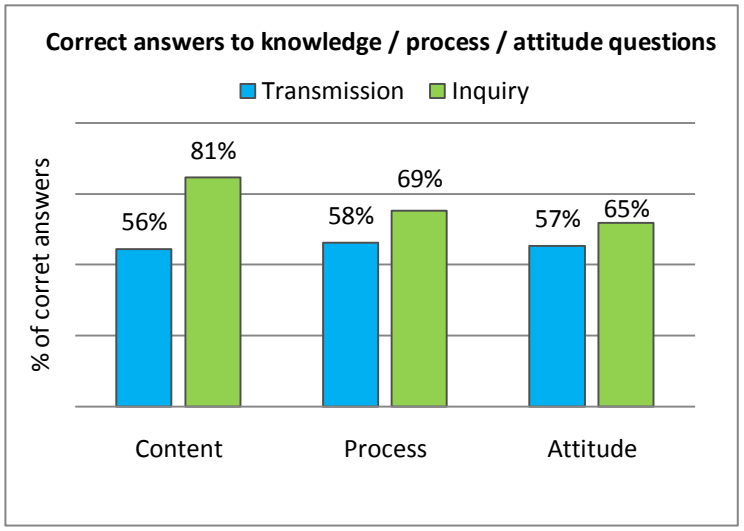
4.3.4.2 Which group had the most correct answers?

Graph 39 shows how large a percentage of all questions, open questions and closed questions have been answered correctly. As you can see the inquiry has a higher percentage in all three categories, the transmission group has an average of 57% correct answers where the inquiry group has an average of 72%.



Graph 39: Pecentages of correct answered to "all", "open" and "closed" questions.

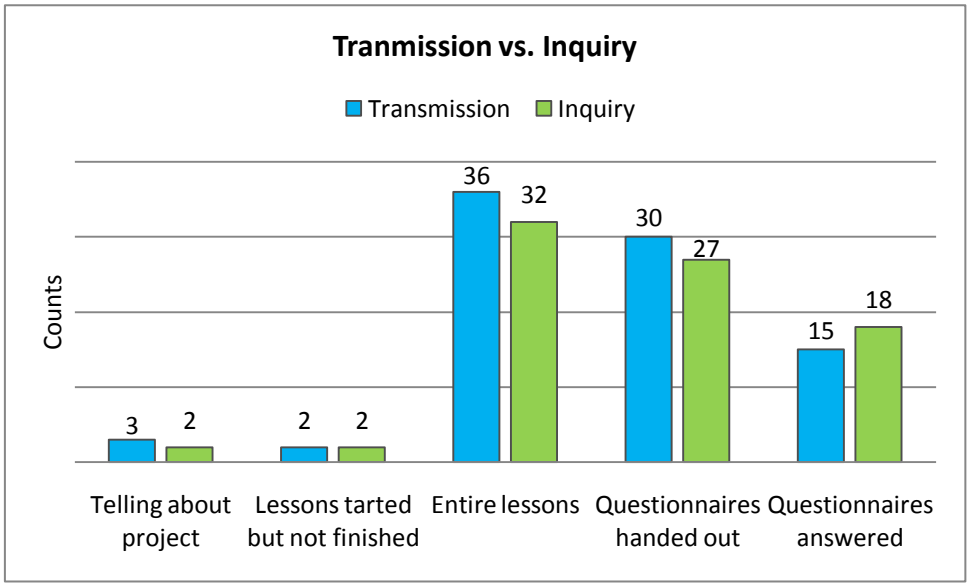
Graph 40 shows the percentage of correct answer of each of the categories "Content", "Process" and "Attitude". Again the inquiry group has a higher percentage in all categories than the transmission group. Only 56% of the transmission group answers to the content questions are correct, here the inquiry group has a percentage of 81%. 58% and 69% of the transmission and the inquiry groups (respectively) answers to the process questions are correct. The difference between the two groups within the attitude questions is a little smaller; however 65% of the inquiry group answers are correct, where only 57% of the transmission group answers are so.



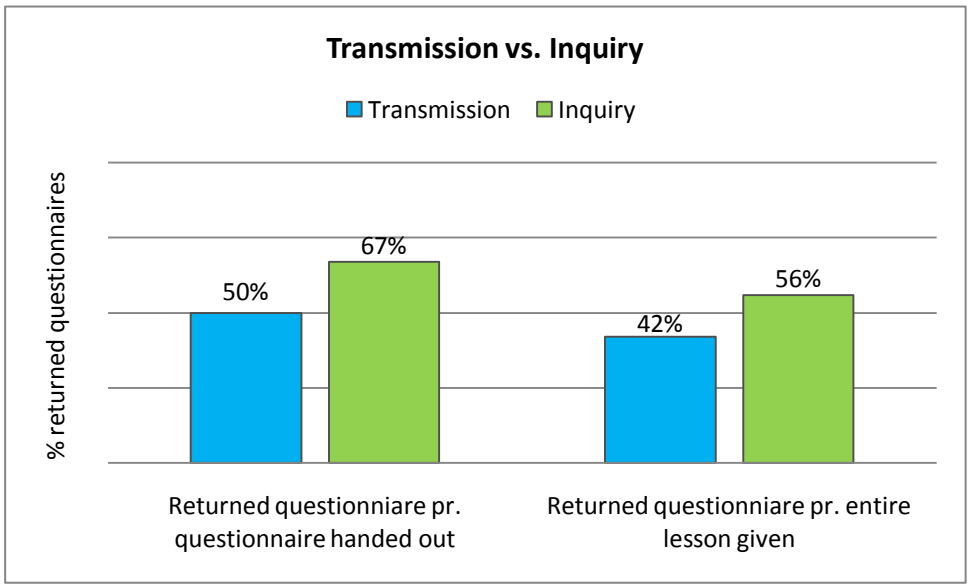
Graph 40: Pecentages of correct answered to "content", "process" and "attitude" questions.

4.3.4.3 Number of learning experiences and questionnaires handed out.

Graph 41 shows how many entire learning experiences (lessons) were given of each type and how many questionnaires were handed out and received back. It also shows how many learning experiences I began and was unable to finish due to other circumstances (kids getting bored, feeding was announced over the speakers) and how many times I just told visitors about why I was standing there with all my equipment. As you can see I had to do more of the transmission learning experiences to try to get as many questionnaires as for the inquiry (graph 42).



Graph 41: Number of lessons, questionnaires handed out and received back of transmission and inquiry.



Graph 42: Percentages of questionnaires returned pr. handed out and pr. lesson given of transmission and inquiry.

5.0 Discussion

5.1 The welcoming poster & the Shark Quiz

An unpublished study about the expectations of the visitors, and how to avoid disappointing them was done by Lisa Varndrup at the Danmarks Akvarium (Varndrup 2010, unpub.). In this study some of the visitors actually expressed disappointment about the lack of activities (games, touch items etc.), and I thereby figured that a small quiz was just the thing to catch the audience's attention and make them seek me out. However, as mentioned in the results I didn't get any response on my poster or shark quiz. I must admit that I am a little baffled about this because I sincerely thought it eye catching and fun, however I think there are three main problems with a setup like mine in a place like Danmarks Akvarium, 1) audience demographic, 2) intimidating display and 3) the fact that people who come here, may just want to walk around and relax without necessarily having to think too much. The demographic composition of visitors at the aquarium mainly consists of families with small kids (or daycares with even more kids) who are in a hurry to go explore. The second issue is that the display of my poster was a bit intimidating to begin with, the poster was placed on two small baby blue (matching the poster) tables with the poster on the top table and an answering box and a small magazine rack for the shark quiz at the bottom table, on each corner I had attached 3 small IKEA pencils (see appendix 2) so as to make sure there were enough for everybody (obviously this turned out not to be a problem). However, on the second day Stephen Maze (the "go to guy" at the aquaria when it comes to drawing and design) walked by and gave me some tips on how to make it more simple. First of all he told me to place the Shark Quiz in front of the poster on the top table instead of in the magazine rack and he also suggested that I might want to leave only one pencil hanging on each corner to make the overall look less messy. Unfortunately these changes didn't have any measurable effect, but even so it definitely looked better and less intimidating. The last issue has to do with the individual audiences and Sarah E. Klein did a touch-table and inquiry method study at two zoos where she observed families as they were investigating her materiel. Several times she noticed parents avoiding her display or drawing the kids' attention to other things so as to avoid having to discuss it with their kids (Klein 2011, unpub.). Since I couldn't actually see the poster from my station I do not know if this is the case here, however if the display was a little overwhelming to look at, it would definitely make people avoid it instead of drawing their attention. It is also quite clear, from personal observation, that the visitors do not really read the information signs at the aquaria. My station was opposite a tank

which illustrated tidal flow, every 30 seconds or so a flow of water would surge into the tank (see appendix 6, DVD appendix 2). I observed quite a few times that the kids were interested in what happened and turned to their parents for an explanation, in many cases the parents just said they didn't know and three times I overheard a parent telling their child that "they are probably just cleaning the tank". If this is the level of work the parents are willing to put into a visit to the aquaria, I definitely understand the lack of results of my poster.

5.2 Placement of the senses during the inquiry sense exercise

The placement of the senses during the inquiry sense exercise can be used as an insight into what the "everyday knowledge" about the sharks' senses is. As seen in graph 1 the general understanding is that the shark uses its sense of smell when it is furthest away from its prey, then its hearing, vision and at last its sense of taste when it is closest to its prey. When I asked the participants about their placements they usually noted the following:

1. Taste: "It is the closest because the shark has to be close enough to bite"
2. Vision: "Sharks have very poor vision and therefore have to be quite close to be able to see"
3. Hearing: "I think they hear ok, at least better than they can see" (a few noted that sound is different/better in water than in air).
4. Smell: "Sharks have an incredible sense of smell; they can smell a drop of blood on several kilometers"

When it came to the electric sense the participants seemed to be having even bigger doubts than with the other senses, most likely because as of five minutes earlier they didn't even know it existed. I had wanted the participants to relate the placement of the electric sense to particularly two facts they had experienced during the learning experience:

1. The shark in the movie clip had been quite close before it reacted to the electric field.
2. I had made sure they were aware that the sharks are actually sensing the electric impulses from muscle contractions of their prey, and my hope was that they would realize that these fields are very small and that the shark therefore had to be very close to the prey.

What was most striking to me was that only 1 or 2 related to the movie clip during the explanation of their placement and none of the explanations had anything to do with the fact that the electric fields from muscles must be very small. Mainly they seemed to be guessing and couldn't really

explain why, even so, about 60% got it more or less correct (placement in position 1 or between 1 and 2). About 40% placed it too far away from the fish and their main reason why was that since I had told them that the sharks are really good at this they must be able to sense the electric fields quite far away. I think that the main reason why they couldn't explain the placement of the electric sense lies in the amount of unfamiliar knowledge they are given in a relatively short time, if I had asked them a little later when they had had time to digest and discuss the information maybe they would have done better.

So, the everyday knowledge regarding sharks were that sharks have poor vision and that the sense of smell is the best of the sharks senses, also, the participants in general didn't know much about the sharks sense of hearing and since they didn't have any prior knowledge about the fact that sharks have an electric sense did not have any preconceptions about this.

Since this everyday knowledge isn't true (sharks have very good vision and the best sense is hearing and not smell) I have to make sure to correct it both in an inquiry way and a transmission way, so to speak. This had to be done without confusing the participants even more, and the problem with everyday knowledge is that it can be difficult to replace or modify because it can be as "set in stone", like trying to write with the wrong hand. According to Piaget individual knowledge is contained in schedules and new knowledge is gained by either assimilation or accommodation into the existing schedules (Winsløw 2006; Damberg *et al.* 2006). In the case of mistaken everyday knowledge there is a definite discrepancy, and the way to change this is to make this discrepancy explicit, by showing them the mistake and then letting them decide how to fit this new knowledge into their existing schedules. This is easier with the inquiry method, first and foremost because the teacher is more aware of what the "student" is thinking and what their exact everyday knowledge may be. When doing pure transmission you have no way of knowing this and teaching has to be based on prior experience. Luckily I could assume that the preconceptions of the transmission group would be the same as those of the inquiry group and I could thereby use the knowledge I had gained, doing these sense exercises to know what the transmission group needed to be taught.

5.2.1 Everyday knowledge about sharks in the general population

There are a few mistaken everyday understandings (everyday knowledge) when it comes to sharks. One of the most common are that sharks are stupid, primitive killing machines which kill everything in sight. Additionally, until the 1960s the official knowledge was that sharks were mainly guided by their noses, and that they had very poor vision. Because of lack of communication

to the general public many still consider this to be true, and I will honestly admit that I had the same understanding before I started reading a little more about sharks for this project. One reason for this understanding is that before 1960, there had been a series of experiments with the sharks senses, where they had removed their sense of smell, and then observed their response to prey. Surprisingly the sharks hardly reacted without their sense of smell, and this led to an everyday understanding that sharks were mostly dependent on their noses. This, however, has been disproven since, and the real reason for the observed lack of response is that sharks are extremely dependent on the interaction of its senses.

5.3 The questionnaire

5.3.1 Content questions

A quick overall look at the results from the three knowledge questions show that the inquiry group seem to be a little better at answering the content questions than the transmission group and graph 40 confirms this suspicion. Even though there were only found a significant difference between the two groups' answers of Q1, I feel confident in saying that the inquiry group is better at remembering facts from the learning experience than the transmission group, though a few more content questions in the questionnaire would have helped to clarify this. The most likely reason for this difference is the hands on approach during the inquiry learning experience and the fact that the participants take part in the explanations and construction of meaning for themselves. As mentioned learning science has a social context which is more engaged by the inquiry than by the transmission method. Real meaning is socially constructed and not just handed from one person to another because different people have different prior conceptions and different resources and thereby different abilities of personalizing the given knowledge (Abell *et al.* 2007).

5.3.2 Process questions

It is little more difficult to assess whether one group answered the process questions better than the other. The two groups are more or less equally good at answering Q5, Q6, Q9 and Q11, however there is a near statistical difference between the two groups answers of Q10 so the inquiry group seem to be better at inferring why you should remain calm and collected when swimming with sharks. I would like to highlight the result of Q8 where you can see a definite and even significant difference between the two groups. The question is about which shark type has most use of its electric sense, the transmission group seemed to agree that it was the shark hunting ON the bottom

and the Inquiry group seemed to think it was the shark hunting IN the bottom, however their explanations (Q9) are much alike, most answered either "they can't see" or "they can't use the other senses". My thoughts when I made this question were that they were supposed to think about where the shark can't use its other sense (e.g. taste, vision, smell, and hearing) so essentially most of them were actually thinking correctly, however, since I told them that smell and hearing are mainly used on greater distanced they should have realized that it is the sense of sight which is the most important sense when answering this question, and that sharks can easily see prey ON the bottom but not IN the bottom and apparently the inquiry group was better at making this connection than the transmission group. According to Hattie (2009) the inquiry method is especially good for learning process skills especially for biology and physics student, and it worked better with smaller kids than kids who had reached their final school years.

5.3.3 Attitude questions

The goal with the attitude questions was to see if there was a difference in attitude between the two groups after the learning experiences. Q3 and Q4 can be used as a very simple test of normality, since they are based on past experience with eating or buying shark products they should be about the same for the two groups, and the results confirm this, there is no statistical difference and the percentages are also more or less the same for the two groups. Q13 and Q14 showed a tendency for the inquiry group to say no to eating shark items compared to the transmission group. However when I compared the percentage of "have eaten prior" to "will eat in the future", twice as many as "had eaten sharkmeat prior" would like to try eating it in the future, and about the same number of people would like to eat sharkfin soup again, but fever would like to buy shark souvenirs in the future, and the percentages were alike for inquiry and transmission. The best result from these questions would have been that no one wanted to eat/buy shark items in the future; however, my learning experience definitely didn't have that effect on the participants. The strange thing is that many noted on the questionnaire that it was downright despicable to buy shark souvenirs, however they don't seem to mind killing and eating the sharks.

The only statements which near significance in Q12 are "sharks are typically dangerous" and "I want to know more about sharks", where the inquiry group do not think sharks are dangerous and the transmission group want to learn more about sharks. Q16 which is much like Q12 in composition and it doesn't really show anything either. I think the main problem with this type of question is that they are too easy to answer without thought and therefore people have a tendency to

just blindly write answers which are on the more positive side of neutral so as to make the person asking the questions (i.e. me) happy.

According to Hattie (2009) the inquiry method should also improve the students attitude towards the subject and although I cannot confirm or deny this based on my study, though graph 40 discussed below do show a tendency for better attitudes in the inquiry group, I think the reason mainly lies within my questions and how they are asked and not within the participants attitudes. From personal observation I found that the inquiry group seemed more content and interested during and after each experience, and it was extremely difficult for me to read what the transmission group thought about my learning experiences because the only time I got actual repeatable responses from them was when I told them how small electric fields the sharks could actually sense (100.000.000 times less than a 1.5 volt battery).

5.3.4. General analysis of the questionnaire

There is only a slight difference in which group answered the most of the questions, However there is a difference between how many of each type of learning experience (e.g. transmission and inquiry) I had to do to get the same amount of results, The transmission group was not as good as the inquiry group to actually return the questionnaires, this leads me to think that maybe the inquiry group has a greater interest in helping me, and that I might have engaged them more than the transmission group.

When it comes to answering correct, the inquiry group is better at all types of questions, open, closed, content, process and have better attitude (i.e. graph 39 and 40) though the difference between the two groups answers of the attitude questions is smaller, and it is clear from the earlier discussion of the attitude questions that the attitudes do not differ so much between the two groups.

5.4 Conclusions

My first conclusion is that the transmission method is a lot harder and extremely draining to carry out since there is absolutely no response from the participant, and I was beyond tired after a day of transmission learning experiences. The inquiry method on the other hand is fun, and I felt good every time I had done one of these learning experiences, even though I was still tired from standing for so long my head was still clear at the end of the day.

There is a real danger when doing this type of lesson at a place like Danmarks Akvarium, at first sight it looks like a fun game and most adults assumed that it was mainly for the kids (even small kids). I witnessed a grandfather tell his grandchild "listen" in a very harsh manner after which he withdrew to the background with a sour look, and some parents just came to me and told the kids to pay attention while they walked away to look elsewhere. The problem with this was that I really needed the adult's attentions as well, because it wasn't just a simple game, to be able to follow you need a basic understanding of what senses are and to some extend you also need to understand the most basic concepts of electricity. Also, the questionnaire was definitely not meant for children. Therefore I can also conclude that I probably should have considered more what I "seemed to be promising" the visitors, because I could sometimes see that they had, had a different idea when they agreed to participate.

By personal observation I also got an idea of how old the kids need to be, before they can follow. When the kids were under the age of 4 they could only participate by placing the sharks senses on the whiteboard. When they reached the age of 5 they seem to understand the concept of senses and which sense humans have, however the concept of electricity was still too abstract for them. Kids older than 6 seemed to be able to follow quite well and also have sufficient prior knowledge about the concepts of both senses and electricity to be able to follow most of the learning experience. Another personal observation with regards to the willingness of adults with kids to participate, show that parents with kids above the age of 6 seemed to enjoy the inquiry learning experience more than parents with younger kids. Younger kids couldn't follow the learning experience and I thereby lost their attention quite rapidly and the parents then had to divide their attention between me and a child who would rather go see the tidal flow across from my station. The transmission learning experiences may be better for families with younger kids because they do not take as long, however, they won't learn as much either.

My final conclusion is that by personally investigating (inquiry) of the various shark senses the participants get a more familiar relationship with this animal and their biology, and thereby a greater memorable understanding of the fact that sharks are definitely not primitive, mindless killing machines, i.e. the inquiry group thinks sharks are less dangerous than the transmission group.

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Anders Kofoed (overall help and encouragement, and tips on what to say and NOT to say when acting as a pilot for the visitors)

Stephen Maze for ideas about how to make my poster display more simple and less intimidating.

The inventor of cable strips without whom this project would not have been possible!

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6.2 Web link references

1) http://en.wikipedia.org/wiki/Brownbanded_bamboo_shark (web link 1)
2) www.IUCN.dk (web link 3)
3) www.akvarium.dk (>Danmarks Akvarium > Historie) (web link 2)

Spørgeskema til formidlingsoplevelse om hajens elektriske sans

1. Skriv sanserne ind, således at den sans hajen kan bruge på størst afstand, også er den sans der placeres længst væk fra hajen på tegningen: **syn, lugt, elektrisk, smag, hørelse**

1) 2) 3) 4) 5)

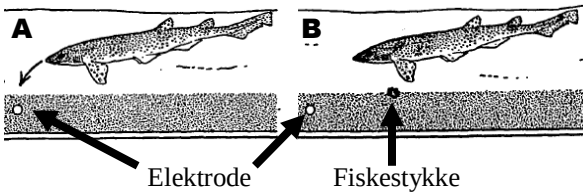
2. Hvorfor bruges sanserne i sektion 4 + 5 i spørgsmål 1 hovedsageligt på længere afstande?

3. Har du spist haj kød eller haj finne suppe?

Haj kød	Ja	Nej
Haj finne suppe	Ja	Nej

4. Har du nogensinde købt haj souvenirs (tænder, kæber, finner el.lign.)? Ja Nej

5. Billede **A** viser en haj reagere på en elektrode begravet i sandbunden. Billede **B** viser en begravet elektrode og et stykke fiske liggende på bunden. Tegn en pil på billede **B** der viser om hajen vil reagere på elektroden eller fiskestykket



6. Forklar hvorfor hajen vælger at reagere på elektroden eller fiskestykket i spørgsmål 5.

7. Hvad er det hajerne kan "mærke" ved deres bytte når de bruger deres elektriske sans til at jage?

8. Hvert år registreres ca. 41.000.000 hajer som fanget/dræbt (til fødevarer og industrielle produkter - læder, medicin, hajer til akvariebrug osv.). Marker på linjen hvor mange hajer du mener der ud over disse dræbes men ikke registreres (bifangst og finner til haj finne suppe)?

0 mill. 25 mill. 50

9. Angiv hvor enig du er i følgende udsagn

	uenig ☹		neutral 😐		enig ☺
Vi bør gøre mere for at beskytte hajer	☐	☐	☐	☐	☐
Generelt bør hajer beskyttes ved lovgivning	☐	☐	☐	☐	☐
Hajer er intelligente dyr	☐	☐	☐	☐	☐
Hajer er typisk farlige	☐	☐	☐	☐	☐
Jeg har fået lyst til at vide mere om hajer	☐	☐	☐	☐	☐
Jeg er bange for at møde hajer når jeg bader	☐	☐	☐	☐	☐
Mit besøg på Danmarks akvarium har været?					
Lærerigt	☐	☐	☐	☐	☐
Spændende	☐	☐	☐	☐	☐
Sjovt	☐	☐	☐	☐	☐
Formidlingen om hajens sanser har været?					
Lærerig	☐	☐	☐	☐	☐
Spændende	☐	☐	☐	☐	☐
Sjov	☐	☐	☐	☐	☐
På et let forståeligt niveau	☐	☐	☐	☐	☐

10. Forklar hvorfor det er vigtigt at være rolig og afslappet når man er i vandet med en haj?

11. Hvilke hajer har størst brug af deres elektriske sans? Dem hvis byttedyr lever…

- ☐ Lige under havets overflade
- ☐ Midtvejs mellem overfladen og havets bund
- ☐ På bunden af havet
- ☐ I havbunden

12. Forklar hvorfor den elektriske sans er mere brugbar for den type haj du har valgt i det foregående spørgsmål?

13. Marker hvor du står i forhold til at spise haj kød eller haj finne suppe i fremtiden?

Ja,vil spise — Vil måske spise — Nej, vil ikke

Haj kød

Ja,vil spise — Vil måske spise — Nej, vil ikke

Suppe

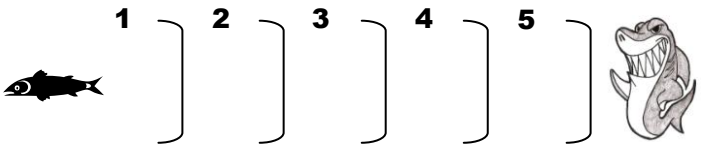
14. Marker hvor du står i forhold til at købe haj souvenirs (tænder, kæber, finner el.lign.) i fremtiden?

Ja,vil købe — Vil måske købe — Nej, vil ikke

15. Forklar kort hvorfor hajerne ikke altid reagerer på det elektriske felt under forsøget?

Spørgeskema til formidlingsoplevelse om hajens elektriske sans

1. Skriv sanserne ind, således at den sans der har størst rækkevidde også placeres længst fra fisken (dvs. størst rækkevidde = 5): **syn, lugt, elektrisk, smag, hørelse**



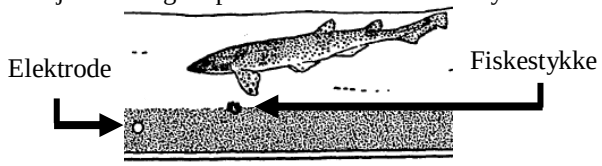
2. Hvorfor bruges sanserne **4** og **5** i spørgsmål 1 hovedsageligt på længere afstande?

3. Har du spist hajkød eller hajfinne suppe?

Haj kød	Ja	Nej
Haj finne suppe	Ja	Nej

4. Har du nogensinde købt haj souvenirs (tænder, kæber, finner el.lign.)? Ja Nej

5. Billedet viser en elektrode begravet i bunden og et stykke fisk liggende på bunden. Sæt en ring på billedet der viser om hajen vil reagere på elektroden eller fiskestykket.



6. Forklar hvorfor hajen vælger at reagere på elektroden eller fiskestykket i spørgsmål 5.

7. Hvad er det hajerne kan "sanse" ved deres bytte når de bruger deres elektriske sans til at jage?

8. Hvilke hajer har størst brug af deres elektriske sans? Dem hvis byttedyr lever…

- ☐ Lige under havets overflade
- ☐ Midtvejs mellem overfladen og havets bund
- ☐ På bunden af havet
- ☐ I havbunden

9. Forklar hvorfor den elektriske sans er mere brugbar for den type haj du har valgt i det foregående spørgsmål?

10. Forklar hvorfor det er vigtigt at være rolig og afslappet når man er i vandet med en haj?

11. Forklar kort hvorfor hajerne ikke altid reagerer på det elektriske felt under forsøget?

12. Angiv hvor enig du er i følgende udsagn

	uenig ☹		neutral 😐		enig ☺
Vi bør gøre mere for at beskytte hajer	☐	☐	☐	☐	☐
Generelt bør hajer beskyttes ved lovgivning	☐	☐	☐	☐	☐
Hajer er intelligente dyr	☐	☐	☐	☐	☐
Hajer er typisk farlige	☐	☐	☐	☐	☐
Jeg har fået lyst til at vide mere om hajer	☐	☐	☐	☐	☐
Jeg er bange for at møde hajer når jeg bader	☐	☐	☐	☐	☐

13. Marker hvor du står i forhold til at spise hajkød eller hajfinne suppe i fremtiden?

	Ja,vil spise	Vil måske spise	Nej, vil ikke
Hajkød			
	Ja,vil spise	Vil måske spise	Nej, vil ikke
Suppe			

14. Marker hvor du står i forhold til at købe haj souvenirs (tænder, kæber, finner el.lign.) i fremtiden?

Ja,vil købe	Vil måske købe	Nej, vil ikke

15. Hvert år registreres ca. 41.000.000 hajer som fanget/dræbt (til fødevarer og industrielle produkter - læder, medicin, hajer til akvariebrug osv.). Marker på linjen hvor mange hajer du mener der ud over disse dræbes, men ikke registreres (bifangst og finner til haj finne suppe)?

0 mio.	25 mio.	50 mio.

16. Angiv hvor enig du er i følgende udsagn

	uenig ☹		neutral 😐		enig ☺
Mit besøg på Danmarks akvarium har været?					
Lærerigt	☐	☐	☐	☐	☐
Spændende	☐	☐	☐	☐	☐
Sjovt	☐	☐	☐	☐	☐
Formidlingen om hajens sanser har været?					
Lærerig	☐	☐	☐	☐	☐
Spændende	☐	☐	☐	☐	☐
Sjov	☐	☐	☐	☐	☐
På et let forståeligt niveau	☐	☐	☐	☐	☐

Skriv din mail adresse her hvis du ønsker at deltage i konkurrencen om en guidet tur bag akvarierne med vores formidler:

Velkommen til Danmarks Akvarium

Vi inviterer alle til at deltage i en SJOV, INTERAKTIV og LÆRERIG oplevelse omkring hajernes 6. sans

Start med at lave haj quizzen

& læg dit svar i kassen

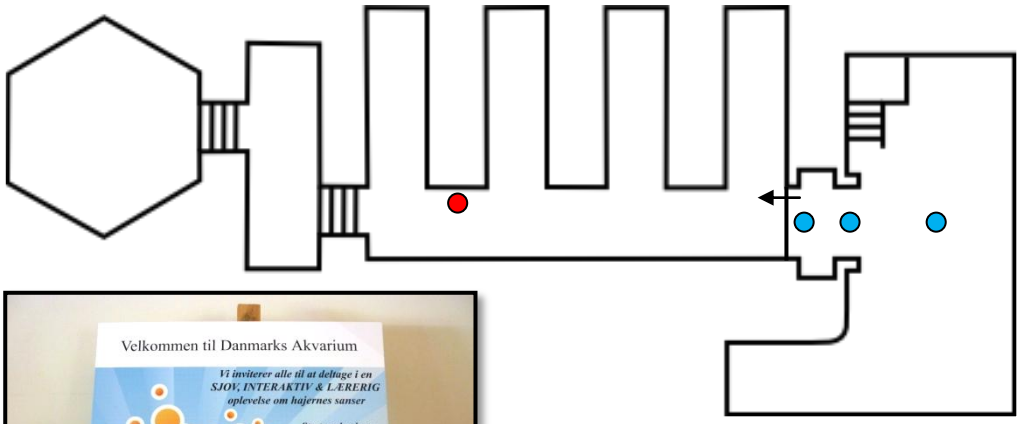
(det korrekte svar udleveres efter læringsoplevelsen)

Vind et guidet besøg bag kulisserne på akvariet Medio juni trækkes der lod blandt alle der har svaret på et kort spørgeskema

Specialestuderende Therese fortsætter oplevelsen ved akvarium 30 mellem 10.00-12.00 og igen 12.30-14.30

Specialestuderende Therese fortsætter oplevelsen ved akvarium 30 mellem 10.00-12.00

Specialestuderende Therese fortsætter oplevelsen ved akvarium 30 mellem 12.30-14.30



My station

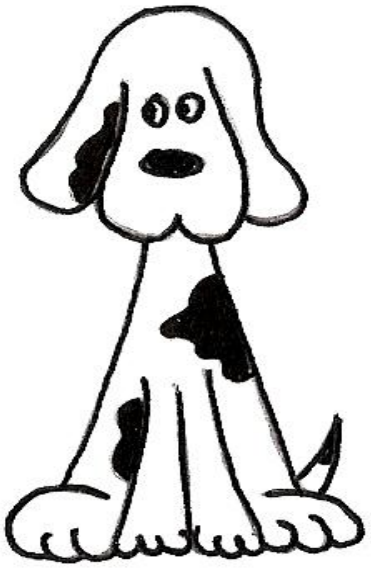
Different placements of the poster

Arrow: entrance to the different tanks

HajQuizzen

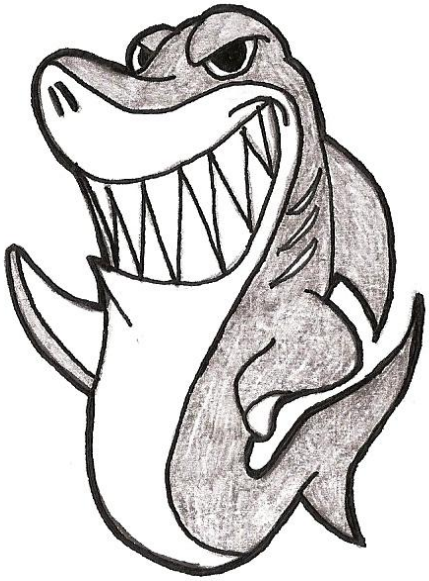
Hvad dræber hvor mange mennesker hvert år??

Forbind hvert billede med et antal!



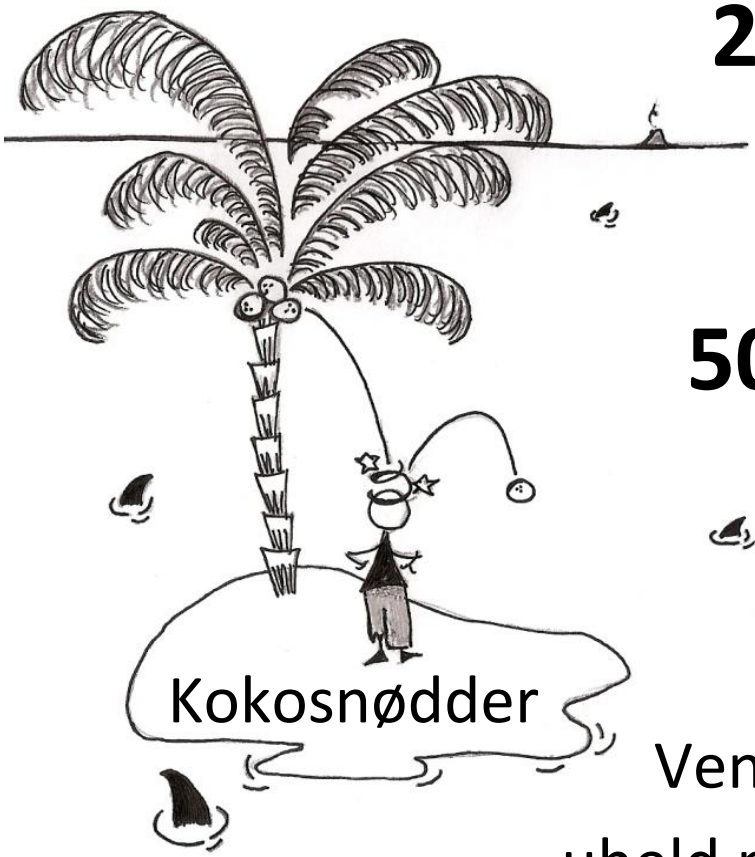
Hunde

5-10



Hajer

150



Kokosnødder

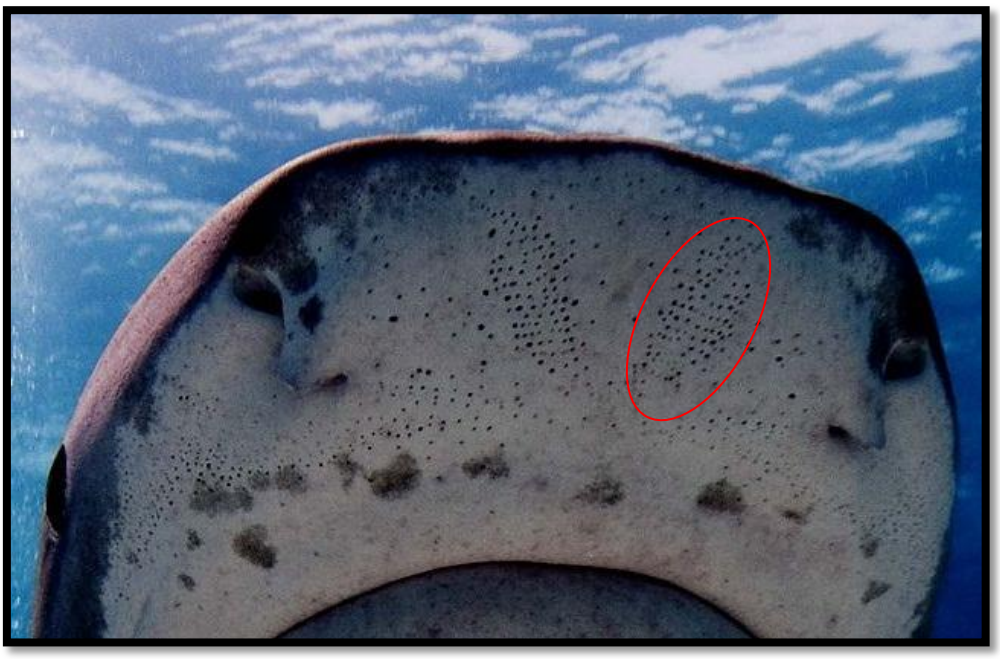
2.500

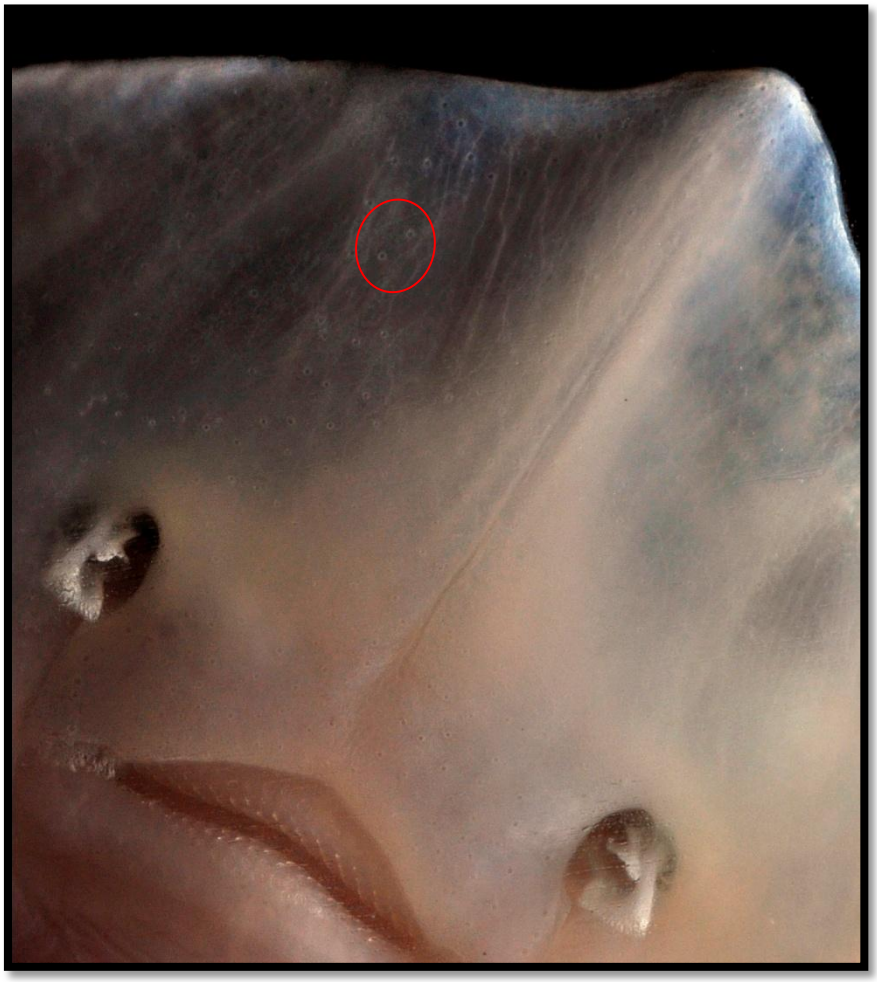
50.000

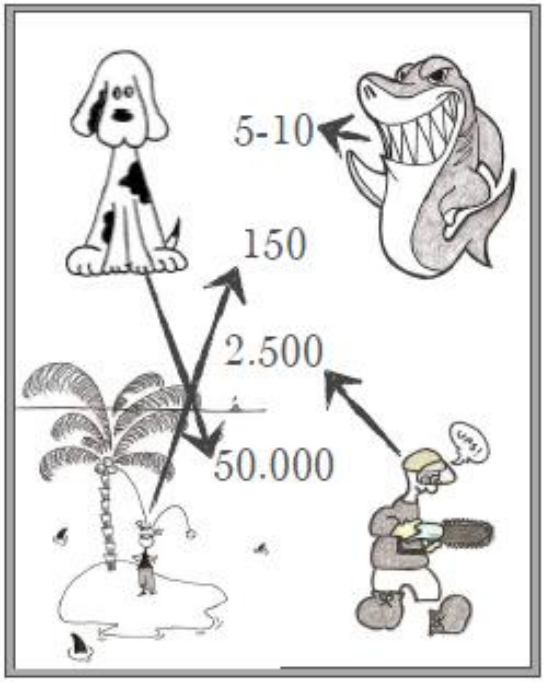
Venstrehåndede dræbt under uheld med højrehånds redskaber

Ampullae of Lorenzini

The sense organs in sharks and rays which sense electric impulses in the water, they can be seen as small holes into the skin around the snout and mouth







Svar på HajQuizzen

Hajer: 5-10

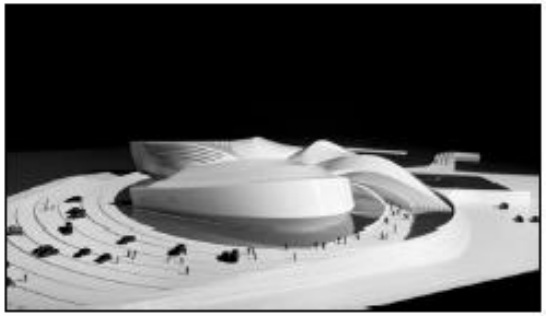
Kokosnodder: ca. 150

Venstrehåndede omkommet efter ulykker med højrehåndsudstyr: ca. 2.500

Hunde: ca. 50.000

De fleste bliver overraskede når de får at vide at hajer rent faktisk kun dræber 5-10 mennesker hvert år, og generelt kan man sige at hajangreb i høj grad adskiller sig fra f.eks. angreb fra andre rovdyr. Hajer angriber typisk ikke pga. sult men af nysgerrighed - de føler med munden.... Desværre kan vi mennesker bare ikke tåle når de føler!

De andre tal i denne quiz er måske endnu mere overraskende??



VI GLÆDER OS TIL AT SE DIG PÅ DET NYE DANMARKS AKVARIUM ANNO 2013

Danmarks AKVARIUM

FAKTA OM HAJER

OG

Af Specialestuderende Therese R.F.

TANKEVÆKKENDE FAKTA

Hvert år bliver 5-10 mennesker dræbt af hajer

Til sammenligning dræber kokosnødder 150 om året og hunde dræber mere 50.000 om året

Hvert år dræber vi mere end 41.000.000 hajer, dette tal dækker dog kun de registrerede drab!

Registrerede drabte hajer bruges i industrien til:
Kød til fødevarer
Læder
Haj lever olie (smøremiddel, kosmetik, vitamin A)
Levende individer til akvarier m.m.
Tænder og kæber som sælges til turister
Haj brusk ("behandling" af kræft og andre lidelser)

Herudover produceres hvert år knap 5000 tons hajfinner til bl.a. hajsuppe, omregnet til antal hajer svarer det til ca. 16.400.000 hajer

Under hajfinne produktionen bliver resten af den til tider levende haj ofte kasseret (dermed ikke registreret) efter finnen er skåret af

Reelt set er det rigtige drabstal derfor nok minimum oppe omkring 60.000.000-70.000.000 hajer pr. år

Til den der vil vide lidt mere...

HAJ TRANCE ELLER TONIC IMMOBILITY...

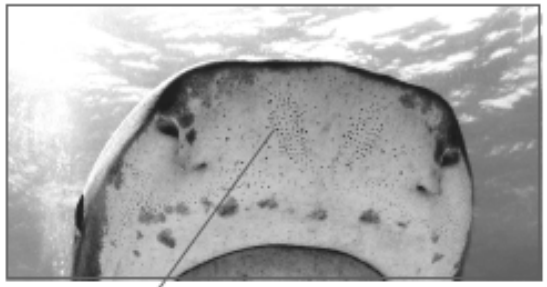
Tonic immobility er en tilstand som kan induceres på to måder, den ene er at vende hajen på ryggen (bedst med mindre hajer) eller ved at placere hænderne roligt rundt om snuden. Begge metoder får hajen i en form for trance, hvor både vejrtrækning og muskelkontraktioner afslappes. Det er stadig en meget ny opdagelse og forskerne har endnu ikke en forklaring på hvad det er der gør at hajerne kommer i denne trancetilstand, men det menes at hajen ved snudeberøringen bliver udsat for en slags "sensorisk overload", og dette kunne måske have noget at gøre med den elektriske sans.

Søg på følgende ord på YouTube og se klip der vil facinere enhver:
Shark Tonic; Sharkman; Michael Rutzon (se billedet til højre)

EN SIMPEL FORKLARING...

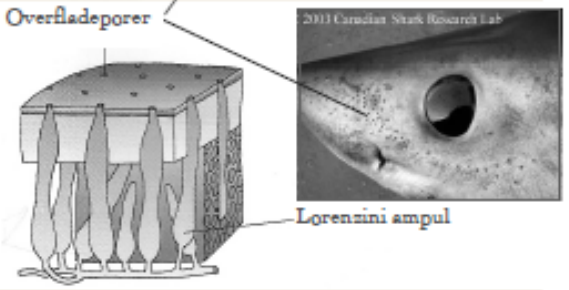
Den elektriske sans er styret af de såkaldte Lorenzinke ampuller. Ampullerne kan ses som små porer i huden omkring hovedregionen på hajerne og desuden ud langs "vingerne" på rokker.

Når hajen bevæger hovedet aktiveres forskellige porer og således kan hajen sanse hvor det elektriske signal kommer fra.



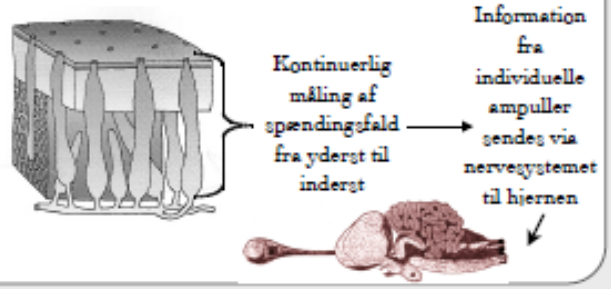
EN DYBERE FORKLARING...

Hullerne i huden danner indgangen til kanaler fyldt med en elektrisk ledende gelé. Længden af kanalerne er forskellig fra art til art og er også afhænging af om den er saltvands- eller ferskvandslevende. Men generelt kan man sige at jo længere kanalen er, jo mere sensitiv er den. Saltvand er meget bedre til at lede elektricitet end ferskvand og derfor har arter der kun lever i saltvand længere kanaler end arter der også kan svømme i ferskvand da der er behov for en større sensitivitet.



EN TEKNISK FORKLARING...

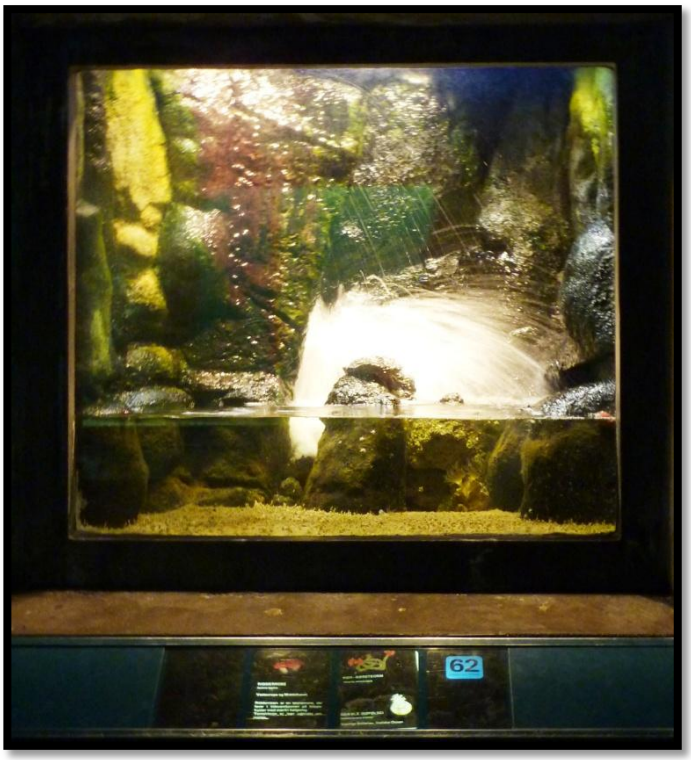
Det der rent praktisk sker når hajen bruger sin elektriske sans er at der konstant måles faldet i spændingen langs de gelefyldte kanaler dvs. hajens sans hele tiden måler forskellen mellem spændingen ved porerne der er i kontakt med det omgivende vand og spændingen i bunden af kanalen, disse oplysninger sendes via nervesystemet videre til hjernen. På denne måde har hajen konstant en fornemmelse af hvordan det elektriske nærmiljø ser ud.



Tadal flow exhibit

Before flow

During flow



Sign describing what happened