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"Science is more fun when I see it in real life"

Changing secondary school students' attitudes towards science with a museum program

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ABSTRACT

The declining trend in positive attitudes towards science among young people is cause for concern in a society filled with challenges that require scientific expertise. To counter this trend, one effective approach in science education is to provide relevant, non-formal learning experiences, complementary to formal science education. Such learning experiences can be found at science- and natural history museums. In the Netherlands, there is a large natural history museum at Naturalis Biodiversity Center. Naturalis offers a wide variety of specialized educational programs that engage students in science. However, not much is known about how these programs contribute to fostering positive attitudes towards science in students. Therefore, eight focus groups were conducted with 25 students from grade 8 and 9, who participated in an educational program at Naturalis. Based on students' reports on three relevant subconstructs of attitudes towards science (perception of the scientist, value of science, and enjoyment of science), five mechanisms are recognized to foster positive attitudes towards science in a museum program: (1) showing diversity in research fields, (2) portraying scientists as people who travel a lot, discover new things, and know a lot, (3) helping students understand more about science, (4) implementing active learning activities, and (5) ensuring an exposure to science through exhibition rooms and objects from the collection. These findings can be used to develop new educational programs, or adapt existing programs, in a way that fosters positive attitudes towards science. Suggestions for implementation and future research are given.

INTRODUCTION

Fostering positive attitudes towards science in students has been a global focus in science education in the last decades, since young people consistently demonstrate less interest in science, and less positive attitudes towards it (Osborne et al., 2003; Tai et al., 2022). These declining attitudes cause students to be less inclined to pursue a career in science (Potvin & Hasni, 2014). This trend is concerning due to the increasing demand of science professionals (NSPE, 2013), particularly given current scientific challenges like climate change and pandemics (Fleming, 2009). This is not saying that the next generation should be the only ones to bear the responsibility of solving societal problems, but it is meant as a way of empowering them to create a society that is right for them.

Declining positive attitudes towards science is not exactly a new problem; there have been large review papers about it in the last decades (Anderhag et al., 2016; Osborne et al., 2003; Yager & Yager, 1985). As a reaction to this, there are several initiatives within formal education to increase positive attitudes towards science (Vennix et al., 2018). Two approaches that are reported to be effective are (1) a more prominent emphasis on 21st century skills, like multidisciplinary problem-solving, critical thinking and creativity, and (2) providing relevant experiences outside of the school context (Vennix et al., 2018). The first approach can be implemented in regular school curricula (Vennix et al., 2018). However, the second approach can be challenging, as it requires schools to organize more non-formal educational activities, which can be time-consuming, expensive, and wrought with practical problems.

A possible solution for this can be found at museums focusing on science and natural history. They provide dedicated educational activities aimed precisely at offering students a relevant and very different educational experience, e.g. the 'Dino Dig Workshop' in London (Natural History Museum London, n.d.), or the 'Science Alliance Program' in New York (American Museum of Natural History, n.d.). In the Netherlands, the largest natural history museum is at Naturalis Biodiversity Center. Naturalis consists of a large geological- and biological collection, which is used for research as well as educational activities. There is a wide variety of educational activities for schools as well as for a general audience, with some activities taking place inside the museum and some taking place outside (e.g., at schools). In the museum, there are educational programs about biodiversity and (earth) science, for primary- and secondary schools (Naturalis Biodiversity Center, n.d.).

While there are many educational programs at museums like Naturalis, there is not much research on the underlying mechanisms on how these programs foster more positive attitudes towards science. Therefore, the aim of this study is to find these mechanisms, focusing on the research question: *how does an educational program in a natural history museum contribute to positive attitudes towards science, based on students' experiences?* Results from this study can be used as advice for museums on how to design new educational programs, or adapt existing programs, in a way that fosters positive attitudes towards science.

THEORETICAL BACKGROUND

In this section, there are two concepts that will be operationalized first: attitudes towards science, and learning in a museum context. Based on these concepts, we will formulate the most relevant subconstructs of attitudes towards science in a museum context.

Attitudes towards science

In general, an attitude towards something can be defined as the positive, or negative, orientation or relation towards a certain object or event (Raved & Assaraf, 2011). According to the ABC-model (Figure 1), attitude can be subdivided into three components: affective, behavioral and cognitive (Breckler, 1985; Millar & Tesser, 1986).

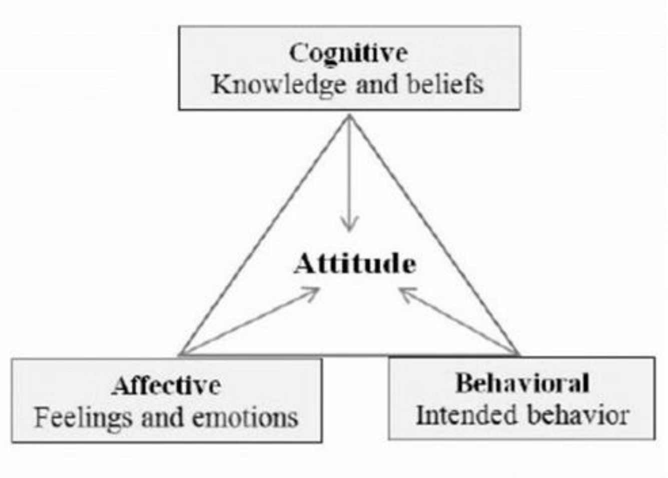

Figure 1. The ABC-model of attitude. From Lee et al. (2015)

Based on the definitions by Raved & Assaraf (2011), we define the three attitude components as follows: (A) the affective component is the emotional relation towards an object. When a person expresses the affective component, they would indicate a certain attraction or repulsion, love or hate, enjoyment or displeasure. (B) The behavioral component is how the person intends to behave towards the object. Note that this is not the same as someone's actual behavior. (C) The cognitive component relates to the rational relation towards an object, which means that this is based on what one knows and beliefs about an object.

As for attitudes towards science specifically, we adopt here an often-cited definition by Osborne et al. (2003): "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (p. 1053). In contrast to the definition of Raved & Assaraf (2011) on attitude in general, this definition excludes the explicit mention of either a positive or a negative orientation, meaning that it includes neutral attitudes towards science as well. Osborne et al. (2003) deconstruct attitudes towards science into several subconstructs, with each subconstruct contributing to someone's attitudes towards science, however not in equal proportions. One subconstruct might be more important for one individual then for another. Osborne et al. (2003) provide a list of the subconstructs that have been included among various studies:

> the perception of the science teacher;
> anxiety toward science;
> the value of science;
> self-esteem at science;
> motivation towards science;
> enjoyment of science;
> attitudes of peers and friends towards science;
> attitudes of parents towards science;
> the nature of the classroom environment;
> achievement in science;
> fear of failure on course. (p. 1053)

Since not all subconstructs are relevant for every study, it is common for researchers to select the subconstructs that are most relevant for the research context. For example, Hillman et al. (2016) developed the MATS questionnaire, a well-known quantitative instrument for attitudes towards science, based on four subconstructs: value of science to society, perception of a scientist, desire to become a scientist, and attitude towards school science. Additionally, Raved & Assaraf (2011) conducted interviews on attitudes towards science based on three subconstructs: perception of the science teacher, value of science studies, and enjoyment of science studies. It is noticeable that both Hillman et al. (2016) and Raved & Assaraf (2011) did not directly copy subconstructs from the above list, but apparently found it more effective to specify the subconstructs themselves. To determine which subconstructs of attitude towards science are relevant for the current study, more information about learning in a museum context is provided in the next section.

Learning in a museum context

Learning in a museum context can be considered either as an informal, or a non-formal learning experience. There is some discussion on the exact definitions of formal, informal, and non-formal learning, but in this study, we apply the definitions from Eshach (2007). This means that formal education is located at schools, with a structured, compulsory, teacher-led structure. Additionally, in mandatory formal education learning outcomes are usually explicitly assessed by grading, e.g., through standardized testing.

As opposed to formal education, informal education can be located anywhere and is more unstructured, voluntary, learner-led, and spontaneous (Eshach, 2007). Importantly, it is usually not graded. Non-formal education shares characteristics with both formal and informal education: it is usually pre-arranged and structured like formal education, but mainly voluntary rather than mandatory. According to these definitions, learning in a museum context can be considered both informal and non-formal, depending on the type of activity. For example, an informal learning experience would be a spontaneous and voluntary museum visit, in which the visitor learns completely in their own way. A non-formal learning experience would be more structured, like participating in a museum program.

Formal, informal, and non-formal learning are not always strictly separate from each other. In a study by Tudor (2013), 60 primary school teachers filled in questionnaires about their opinion on students participating in non-formal forms of education as an addition to their school curricula. Based on their responses, the author concludes that adding non-formal learning experiences in formal education can be beneficial due to an active involvement of the students in their own learning processes (Tudor, 2013). They also explicitly mention that traditional formal teaching strategies should not be eliminated but play an important role in building a solid theoretical foundation, while non-formal experiences can then further maximize the students' learning gains. Additionally, in an essay by Monteiro et al. (2016) it was suggested that the most effective way to diversify the curriculum, is by creating collaborations between schools and non-formal places like museums. As opposed to teachers using non-formal science environments as illustrative visits only, a collaboration could mean that students get to participate in educational activities in museums, while also evaluating those activities (Monteiro et al., 2016). Then, students would see how science is applied in many different contexts, while also reflecting on their learning experience, and museums can keep improving their programs.

Since educational activities can vary greatly between different museums, we need to describe the context of activities at Naturalis Biodiversity Center in order to choose the most relevant subconstructs of attitudes towards science. At this museum, there are various educational activities for primary education as well as secondary education. All activities are developed with the same educational vision in mind, which is to facilitate an inquiring attitude, stemmed from wonder and curiosity (Naturalis Biodiversity Center, n.d.). There are six core values in their educational vision: (1) *wondering* - using wonderment to elicit curiosity, as a starting point for learning, (2) *real* - showing authentic objects and real-world examples, (3) relevant - making the relevance of nature and biodiversity explicit, (4) *inquisitive* - letting people understand nature through inquiry-based learning, (5) *science-positive* - stimulating visitors to appreciate the value of science, and (6) *activating* - encouraging action against loss of biodiversity. (Naturalis Biodiversity Center, n.d.).

Among the various educational activities at Naturalis, there is one program that focuses on letting secondary school students discover their own interest within science (more specifically, earth sciences). Besides discovering their own interests, the main learning goal of the program is to for students to realize the value of a geological collection, both the scientific and economic value. Since this program is the most focused on science and scientists, it is selected for this study to further discover the mechanisms behind attitudes towards science in a non-formal context.

Attitudes towards science in a museum context

When applying the subconstructs of attitudes towards science on the context of an educational program at Naturalis, three subconstructs are the most relevant for this study:

- Perception of the scientist: Osborne et al.'s list (2003) includes 'perception of the science teacher', rather than 'perception of the scientist'. However, with Naturalis being a research institute as well, they let students learn about scientists, and from scientists, more than from a science teacher. Therefore, it was decided to adapt this construct to refer to scientists in general rather than to science teachers.
- Value of science: since Naturalis is explicitly aiming to emphasize a science-positive attitude, and the relevance of preserving nature and biodiversity, it seems appropriate to include value of science to see whether students recognize this core value in the program as well.
- Enjoyment of science: since one of the other core values of the museum is to use wonderment to elicit curiosity, this shows that Naturalis tries to make science enjoyable for their target audiences, making this subconstruct also appropriate for this study.

Subconstructs from the list of Osborne et al. (2003) that are not considered for this study are 'anxiety towards science', because that is opposed to the museum's core value of being science-positive and therefore not likely to be induced by the educational materials. Furthermore, 'self-esteem at science', 'achievement in science' and 'fear of failure' are excluded, due to the non-formal nature of the program, in which students are not being assessed for their performance. The subconstructs of 'attitudes of parents towards science' and 'the nature of the classroom environment' are not considered simply because neither the parents nor any classrooms were present during the program. Lastly, 'motivation towards science' and 'attitudes of peers and friends towards science' could both be considered to be relevant in this context, however there are (almost) no references to these subconstructs in the specific content of the program. Therefore, the three listed above remain: perception of the scientist, value of science, and enjoyment of science.

In order to scrutinize the way these three subconstructs of attitudes towards science are represented in different parts of the educational program, Table 1 provides some explicit quotes from the program material and links them to the three constructs (for the full table, see Appendix A). Based on how these subconstructs are found abundantly in different parts of the program, it is hypothesized that students will mention (some of) these parts in a cognitive, affective, or behavioral manner (ABC-model, Figure 1). For example, when asked about scientists, it is likely that they would describe a glaciologist along the lines of '"a glaciologist studies ice and glaciers to find out the climate of the past and predict the climate of the future." (Table 1), but they would then add whether that is something they would like or not. This would then tell us how the depiction of a glaciologist could contribute to attitudes towards science.

Table 1. Examples of constructs of attitude towards science in the museum program 'How do you find out?'

Part one: introductory presentation (20 min)	*Quote from the script of the program*	*Attitude towards science construct*
	"Collecting in the most remote places on Earth; being an earth scientist can be hard."	Perception of the scientist
	"This is how we learn more about Earth's present, past and future."	Value of science
	"You will be face to face with the most beautiful natural treasures in our museum."	Enjoyment of science
	"This is without a doubt one of the highlights of our mineral collection. This green crystal is a stunning tourmaline of no less than 25 centimeters, that has been fused with a beautiful quartz crystal."	Enjoyment of science
	"The value of treasures from the earth cannot always be expressed in money. At Naturalis, we are particularly interested in the scientific value of the earth. What do we learn from it?"	Value of science

Part two: program in five exhibitions (90 min)	*Quotes from the booklet*	*Attitude towards science construct*
Exhibition Ice Age	"A glaciologist studies ice and glaciers to find out the climate of the past and predict the climate of the future."	Perception of the scientist
Exhibition Earth	"A volcanologist studies volcanoes, lava and eruptions. In this way, a volcanologist tries to predict when a volcano will erupt and what the consequences will be."	Perception of the scientist
	"A mineralogist studies minerals and how they are formed. A mineralogist provides information to jewelers, museums, or customers with gemstones. Sometimes a mineralogist visits a mine or other site themselves.	Perception of the scientist
Exhibition Dinosaur Age	"A paleontologist studies the remains of early life that occurred on land, in the sea or in the air. In this way, a paleontologist tries to understand how life on Earth has changed over time."	Perception of the scientist
Personality test	Various questions about personal preferences related to the work of the four different earth scientists.	Enjoyment of science

METHODS

The aim of this study was to find underlying mechanisms on how educational museum programs foster positive attitudes towards science. However, this topic has not yet been studied extensively. Therefore, a descriptive qualitative research approach was most appropriate, which meant collecting non-numerical data, e.g., spoken- or written words or visual images (Denscombe, 2017). This allowed for rich in-depth data to describe this rather unexplored topic in more details, and close to real-life situations (Denscombe, 2017). An overview of the study is depicted below in Figure 2.

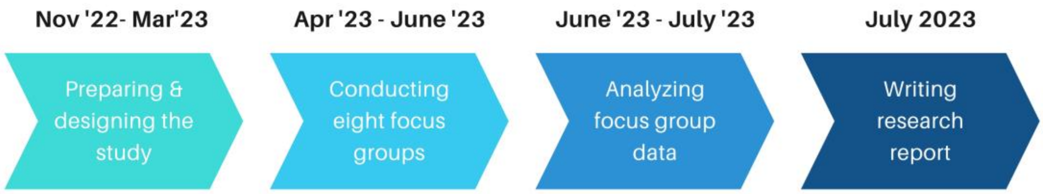

Figure 2. Overview of the study, starting in November 2022 (left) to July 2023 (right). For the complete research planning, see Appendix B.

Context

The museum that was selected for this study was Naturalis Biodiversity Center in Leiden, the Netherlands. Among the wide variety of educational activities, the museum offers some 'exhibition-programs', that are positioned against the background of the nine museum exhibitions. There are four museum programs available for primary schools, and four different programs for secondary schools. While the exhibitions are also available to other visitors of the museum, the difference is that students participating in the exhibition-programs visit the exhibitions with their whole class (and sometimes multiple classes from one school), and they get an assignment that requires them to use information from the exhibitions. Since Naturalis is a biodiversity center, most of these programs are centered around biodiversity- and science topics, like evolution and animal biology. However, there is one secondary educational program that focuses on earth science, and especially on earth scientists - it is called 'How do you find out?'[1].

Since the Dutch school system consists of different educational levels, the program 'How do you find out?' was designed to be inclusive for all levels. To clarify this, the structure of formal education in the Netherlands is depicted in Figure 3. Primary schools are for students between the ages of 4 and 11, which corresponds to kindergarten until grade 6 in the K-12 system. Secondary schools are for students between the ages of 12 and 18, which

[1] In Dutch, the program is called *Hoe vind je het?* which has a double meaning of 'How do you find out?' as well as 'How do you like it?'. There is no translation in English that also conveys both meanings, therefore we only use 'How do you find out?' to refer to the program.

corresponds to grade 7 until 12. While primary education is the same for every student, secondary education is divided into different levels: pre-vocational education (*vmbo-b, vmbo-k, vmbo-g & vmbo-t)*, general education (*havo)*, and pre-university education (*vwo)* (SLO, 2022). The different levels prepare students for different levels of tertiary education (see Figure 3). The program 'How do you find out?' was designed for students in grade 8 and 9 of general education and pre-university education, and grade 9 and 10 of pre-vocational education. In this study, we took into account that students from different school levels might experience the program differently and applied that in the sampling method (see next section).

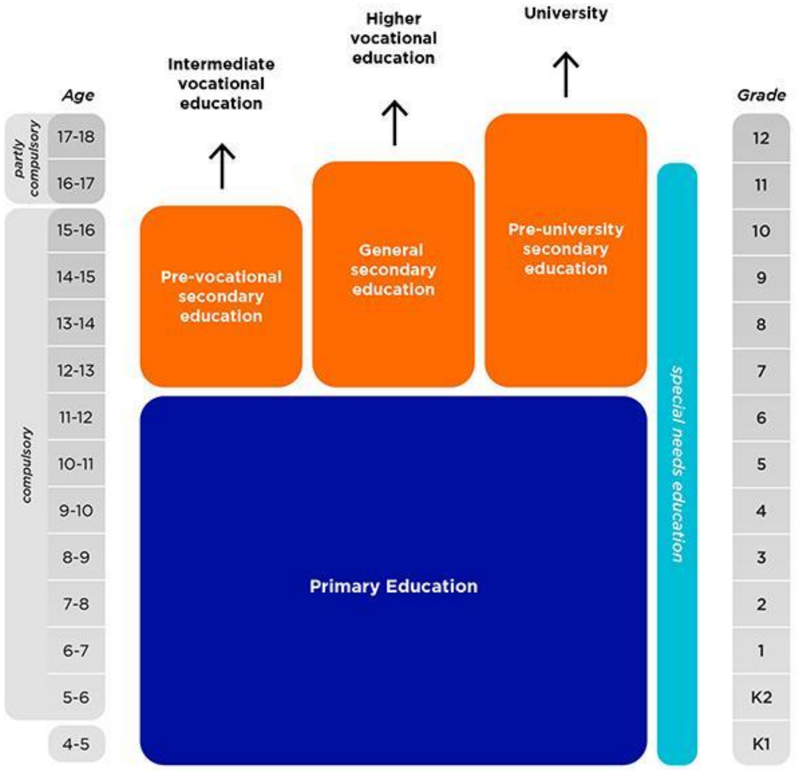

Figure 3. Overview of the Dutch school system, compared to the K-12 system on the right and students' ages on the left (SLO, 2022).

Participants

For this study, students were selected through convenience sampling, meaning they were in school classes that had booked the program independently of this research. During the research period, seven different schools had booked the program, of which four were willing to participate in this research. The other three schools were unable to participate, mainly due to timing issues. Depending on how much free time the students got to spend in the museum, it was possible to organize between one and four focus groups for each school. Since there was one researcher conducting the focus groups, it was not possible to have multiple groups at the same time. This yielded a total of eight focus groups, with 25 students in total (see Table 3). The students were selected by the researcher by purposive sampling, meaning that students were deliberately selected, based on their school level. This was to ensure that there was a wide cross-section of students from different school levels in the sample. If the students were randomly selected, there was a risk of selecting only students from the same level, since there was a rather small sample available. Through purposive sampling, we managed to create a diverse sample of focus groups (see Table 3), which ensured a more complete view on students' experiences.

Table 3. Distribution of students across the focus groups.

Group	*Date of school visit*	*Grade*	*Students*	*Education level*
1	14-04-2023 (school 1)	8	A, B, C, D	General (havo)
2	14-04-2023 (school 1)	8	E, G	General (havo)
			F	Pre-university (vwo)
3	14-04-2023 (school 1)	8	H, I, J, K	Pre-university (vwo)
4	14-04-2023 (school 1)	8	L, N	General (havo)
			M, O	Pre-vocational (vmbo-t)
5	23-05-2023 (school 2)	8	P, Q, R, S	Pre-university (vwo)
6	06-06-2023 (school 3)	9	T, U, V	Pre-university (vwo)
7	09-06-2023 (school 4)	9	W, X	Pre-vocational (vmbo-b)
8	09-06-2023 (school 4)	9	Y	Pre-vocational (vmbo-k)

Before starting with data collection, the contact person of each school was informed about the research and the types of questions, and the four schools that participated agreed that the questions were of such a non-sensitive nature that it would not be uncomfortable for the students in any way. Additionally, the students that were interested in participating were informed (after participating in the program) about the research, the anonymous processing of their data, and their right to refrain from participating at any moment. After informing the students, the focus groups only continued with the students who consented to participating and being recorded on audio.

Instruments

In this study, eight focus groups were conducted (see Table 3). In general, focus group interviews are organized with small groups of people (up to about 20), with a researcher to facilitate the discussion on a specific topic (Denscombe, 2017). For exploring attitudes, perceptions, and feelings about specific topics, conducting focus groups is an ideal method. It allows for in-depth discussion among participants, which provides the researcher with detailed views and opinions and the reasoning behind them (Denscombe, 2017). Additionally, focus groups are less intimidating for secondary school students, compared to one-on-one interviews (Barbour, 2008, as cited in Schmidt & Kelter, 2017)

A group ideally consists of six to nine people, however in small-scale research project like the current study, there is often a smaller number of participants due to practical reasons related to time and budget (Denscombe, 2017). Even though focus groups may last up to 90 or 120 minutes, in the context of the current study, time was limited because schools only had limited time at the museum. Any amount of time that students spent in a focus group took time away from their museum experience. The interview protocol included eight questions in total (see below), executed in a semi-structured manner, meaning that the order of the questions was flexible (except for the opening- and closing questions) and that follow-up questions were applied when needed. This was for example to clarify a student's reasoning behind their response. Every student in the group got the opportunity to answer every question, either explicitly with a direct question from the researcher (e.g., "and what do you think about this?") or more implicitly with the researcher's body language (e.g., turning towards the student who had not responded yet). To ensure data saturation, the closing questions were two open-ended questions about the program and about science in general, aimed at ascertaining whether the students had any additional insights or remarks concerning these topics. For the full interview protocol, see Appendix C. The questions below are translated from Dutch.

Opening questions

1. What did you think of the program?
2. In your opinion, what is science?

Value of science

3. Did this program make you value science more?
   - Follow-up: why was that? / how did the program make that happen?

Enjoyment of science

4. Did this program make you enjoy science more?
   - Follow-up: why was that? / how did the program make that happen?
5. What do you like or dislike about the work of an earth scientist?
   - Additional explanation (optional): for example, an earth scientist is a volcanologist / glaciologist / mineralogist / paleontologist.

Perception of the scientist

6. What new things did you learn about scientists in this program?
   - Follow-up: what did you already know about scientists?

Closing questions

7. What else would you like to say about the program?
8. What else would you like to say about science in general?

Data collection and analysis

During the focus groups, data was collected by audio recording with the researcher's personal phone. No video recordings were made. The audio recordings (190 MB) were stored in accordance with the FI Data Management Protocol of Utrecht University (Universiteit Utrecht, 2023), which meant that the recordings were uploaded from the phone to Microsoft OneDrive, which was connected to an account of Utrecht University and therefore protected with two-factor authentication. Afterwards, the audio data was deleted from the phone. The data was then transcribed verbatim, and quotes were selected and coded bottom-up (Burnard et al. 2008). Bottom-up coding yielded the codebook from Table 4 below. From the 177 quotes in total, 71 quotes were coded by a second coder, using the same codebook. This yielded a

Cohen's kappa of 0,86, indicating that the first- and second coder were in near-perfect agreement.

Table 4. Codebook for the focus group data.

Attitude component	*Category*	*Description*	*Example quote*
Affective	Museum experience+	positive opinions about the museum experience	The museum is built in a really nice way, so you actually want to learn stuff and it's not boring like in a classroom.
	Program+	positive opinions about the program	If you're not using that booklet, you wouldn't know anything.
	Program-	negative opinions about the program	Those assignments are not very fun.
	Science+	positive opinions about science, either related to the program or not	I think [science] is pretty cool. If you can see a T-Rex from 70 million years ago or something, I think there's something important about seeing all these very old things.
	Science-	negative opinions about science, either related to the program or not	I'm not really into sciences, I'm more into other things.
	Scientist+	positive opinions about scientists, either related to the program or not	For me, the positive thing [about being a scientist] would be that you get to explore and discover new things. So, you actually get your name into history if you discover something cool. So then you are part of the development of the world, basically.
	Scientist-	negative opinions about scientists, either related to the program or not	The work of a scientist seems a little boring to me. (...) Because you have to work on one goal. On one stone or something.
Cognitive	Science	neutral view on science, either related to the program or not	Science is everything that's ever invented by humans.
	Scientist	neutral view on (a) scientist(s), either related to the program or not	I didn't really know what an earth scientist was actually. (…) Someone who searches for things in other countries. (…) And in ice cold places. .
Other	n/a	quotes that fall outside the scope of the other categories	I think a questionnaire like that only indicates a direction, but it really doesn't mean anything else.

RESULTS

The focus group data yielded 177 quotes, from 25 different individuals. An overview of the distribution of these quotes across the categories from the codebook is depicted in Figure 4 below. For each category, a few typical quotes were selected to provide more context.

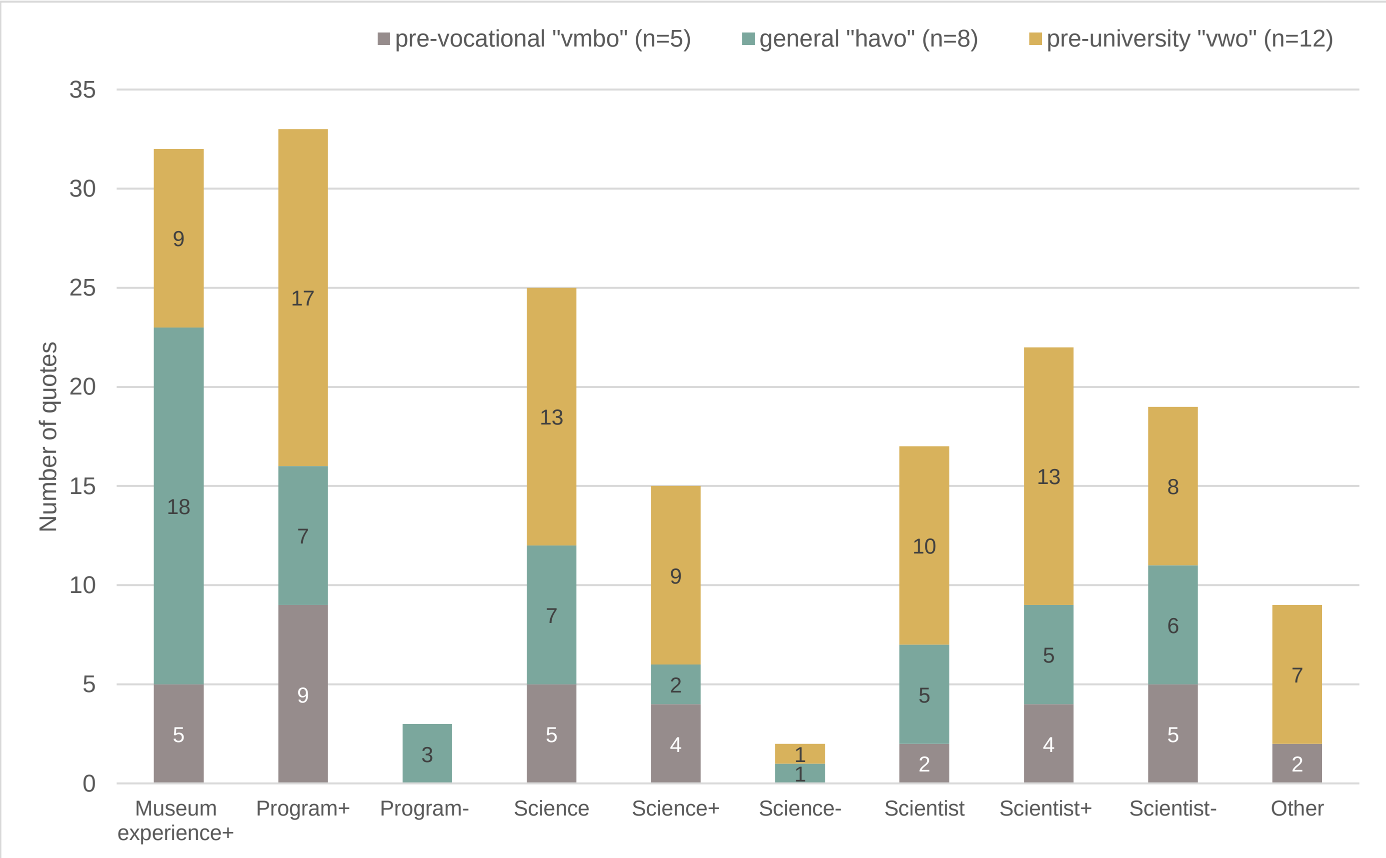

Figure 4. Distribution of quote types across different coding categories and school levels.

From Figure 4, it becomes clear that many positive remarks were made about the museum experience in general (32 out of 177), i.e., not related to the educational program that is the focus of this study. In general, students expressed a lot of positive comments about the program (33/177) and there were very few negative remarks about it (3/177).

Positive museum experience

Many remarks refer to being impressed by the surroundings during the program, for example student L (havo): “The rooms [in the museum] were nice to look at.”. Some students also noticed the effect on the museum experience (rather than the program) on their attitude towards science, like student X (vmbo-b) “You can see nice stuff here, and also stuff that you might not have seen before. And that makes [science] more interesting.” Or student K (vwo):

"I think [science] is more fun when I see it in real life, not only on a screen." This student was referring to seeing real objects from the museum collection.

Program

Another large category was a positive opinion about the program itself (33/177). These were comments that related to activities that were experienced by students during the program, and not by, e.g., other museum visitors. One clear theme in this category was learning in an active manner, for example:

> "I think when you have that booklet, you start looking more actively for an answer, or something else you'd like to know, and that makes it more interesting too. (...) Because otherwise you walk and then you don't take in very much, I think." (M, vmbo-t).

Other students commented on being more aware about science, like student R (vwo): "After the program, you're a bit more aware of how [science] works."

Only three quotes from two different students were negative opinions about the program in general. However, these students did not relate their negative program experience to any aspects of attitude towards science. For example, student A (havo) mentioned: "The program was a bit boring, but that's maybe because it's with school."

Science

General and more factual quotes on science were uttered 25 times, for example: "I think [that science] is research [into] a certain area. For example, suppose you do research on all kinds of rocks, that then you know where to find it and what you can do with it." (M, vmbo-t). Or student J (vwo): "Science is about doing research.".

Students who reflected on how the program depicted science in a positive manner (15/177), mentioned for example: "[The program makes science more important], because you start to understand more about how it works and that makes you think: this is important to research." (student Y, vmbo-k). Not all students had this view though, some students already knew a lot about science, like student R (vwo):

> "I found [science] interesting anyway, and I was already pretty aware of the way it worked. So, it's not necessarily that I started finding it a whole lot more interesting [after the program]. (…) But I think a lot of people did start to find it more interesting."

Even though student R felt like the program did not add to their interest in science, they found that it would be the case for other people. There were also students who were, like R, also already interested in science but who felt like the program added to that anyway: "I do think [the program] makes science more interesting. It's an interesting topic anyway, and it gets more interesting when you hear and read and see more about it" (L, havo). Some students also commented on the diversity of topics within science: “I also think it's surprising that you can make a science out of anything. You can go really into detail about every part of the world. It's very diverse.” (V, vwo).

There were only two quotes addressing negative views on science. These were from students F (vwo): “I'm not really into sciences, I'm more into other things.” and L (havo):

> “Some things [in science] are scary, like the things that are actually going on that you don't know about. That's pretty scary to think about sometimes. (...) because probably not even everything that's actually out there has been discovered yet, probably there's even more than what has been discovered.”

Scientists

As opposed to the three science-categories, the quotes in the three scientist-categories were more equally distributed across neutral, positive, and negative views (see Figure 4). As for the neutral views (17/177), students would mention for example:

> “As a mineralogist, for example, you look at a mineral or at stone, and then you'd look at what color it is, or what materials it is made of. And from that you can tell how warm it was at a certain period in the past.” (R, vwo).

Some students were more in doubt about what a scientist exactly does. Like student A (havo): I don't know if scientists also dig those dinosaur bones out of the ground in other countries, but they do examine those bones that are extracted from the ground.” Or student W (vmbo-b): “I didn't really know what [an earth scientist] was actually. (...) Someone who looks for things in other countries. (...) And in ice-cold places.”

As for positive views on scientists (22/177), seven students mentioned going to other places, like: “If you're a volcanologist, I think it would be nice to see all those volcanoes in real life. To be there, that's really special” (H, havo). Another frequent view was about exploring new things: “For me, the positive thing [about being a scientist] would be that you get to explore and discover new things. So, you actually get your name into history if you discover something cool. So then you actually are part of the development of the world, basically.”

Going to other places was not only mentioned positively, but also as something negative: “What I like less is that [as a scientist] you have to travel a lot. (...) That you're away from home a lot, less likely to see family, and friends. And that sometimes you have to go abroad.” (Y, vmbo-k). Additionally, students mentioned that they thought the work was boring: “[The work of a scientist] seems a little boring to me. (...) Because you have to work on one goal. On one stone or something.” (B, havo). And some students mentioned that they would not enjoy the work of a scientist, because it requires having a lot of patience: “I don't think it's very enjoyable [as a scientist] to be so patient and having to figure things out all the time. And as a paleontologist, for example, you're busy with all the sand dusting and things like that.” (P, vwo).

Other remarks

Lastly, there were some quotes that did not seem to fit in any other category. These were for example: “I think a questionnaire like that only indicates a direction, but it really doesn't mean anything else.” (R, vwo).

CONCLUSION

The research question in this study was *how does an educational program in a natural history museum contribute to positive attitudes towards science, based on students' experiences?* Interview questions were based on the three relevant subconstructs of attitudes towards science in this context: perception of the scientist, value of science, and enjoyment of science.

Based on students' experiences, the program adds to their perception of scientists by creating insight in the diversity among earth scientists. For example, by portraying four earth scientists who are all specialized in a different field (glaciology, paleontology, mineralogy, and vulcanology). Some students like this diversity, but for some students it creates the image that working as a scientist is boring, since a scientist would be focused on one very specific topic. Furthermore, students perceive scientists as people who travel a lot, discover new things, and know a lot. Although traveling a lot is not perceived only as something positive, because some students consider it a disadvantage.

The second subconstruct, the value of science, is also enhanced by this program by portraying the diversity in research fields. This shows students how science can be relevant in different aspects of the natural world. Additionally, the program increases valuing science by helping students understand more about science, by showing concrete examples of scientific findings. For example, the booklet describes the finding of the *Homo erectus* skullcap by Dutch paleontologist Eugène Dubois, and how he first thought it belonged to an ape, but later thought that it was more like a missing link in human evolution. This finding is described in the museum exhibitions as well, but the program booklet adds a question about it, to let students find the differences between themselves and early humans. This helps them to look at the finding from a different perspective then a regular visitor would.

Lastly, the subconstruct enjoyment of science is stimulated both by the program itself and the environment of the program. In the program itself, this is achieved through the implementation of active learning activities. Notably, students express a high level of enjoyment in engaging with these activities. An example is the activity in which students perform small tests on different minerals, to answer questions like "which minerals are magnetic?". As for the environment of the program, that enhances enjoyment of science through exposure to the exhibition rooms and objects from the collection, which are all presented in a way that elicits wonderment and curiosity (e.g., the mineral room is designed to give the impression of going into a mine).

In conclusion, there are five mechanisms found in this study that contribute to positive attitudes towards science in the educational program 'How do you find out?':

- Showing diversity in research fields.
- Portraying scientists as people who travel a lot, discover new things, and know a lot.
- Helping students understand more about science.
- Implementing active learning activities.
- Ensuring an exposure to science through exhibition rooms and objects from the collection.

DISCUSSION

This last section will first discuss the limitations of this study, then the implications of the findings and lastly provide a direction for future research on this topic.

Limitations

During data collection, a notable observation was that students mentioned no negative museum experiences, and hardly any negative things about the program itself, and about science. This could have been due to an interviewer effect: since the interviewer was older than these students and presenting as both a researcher, and an employee at Naturalis, the students could have given more positive responses, thinking that those would be more socially accepted. However, this effect would be difficult to avoid, except for when students would be interviewed by a peer, but that would not be appropriate due to these students not having the same research skills.

Furthermore, in studying attitudes towards science, there is always a limitation in selecting relevant subconstructs. As mentioned in the theoretical background, there were two subconstructs of attitudes towards science that could have been included but were omitted due to the incongruence with the program's content. These were the constructs 'motivation towards science' and 'attitudes of peers and friends towards science'. When reflecting on the research process, it can be concluded that omitting 'motivation towards science' was appropriate, since it would have been challenging to explore such a complex construct in a short focus group. However, the construct 'attitudes of peers and friend towards science' could have been briefly considered in addition to the three subconstructs that were already selected. This is because during the selection of students for the focus groups, it became apparent that students often walked through the museum with their friends. It also occurred on a few occasions during the focus groups, that students indicated that they shared the exact same opinions as their friends. That indicates that the attitudes of peer and friends could have been a relevant subconstruct in this study. However, since this study included as much diversity as possible among the student populations between the focus groups, the chance that important mechanisms were missed is not high.

Implications

The five mechanisms mentioned in the conclusion can be used as advice for museums on how to design new educational programs, or adapt existing programs, in a way that fosters positive attitudes towards science. The program 'How do you find out?' shows some concrete examples of how to enhance attitudes towards science on the three selected subconstructs (see conclusion), like showing different scientists, showing concrete examples of scientific findings, and letting the students test minerals themselves.

However, students also reported on elements in the program that did not contribute to any aspect of attitude towards science. This was mostly about the personality test at the end of the program booklet. This test was either not completed at all, or completed very quickly, or not taken seriously. It would be worth considering to either remove this test, or adapt it, or put it more in the beginning of the program instead of at the end when students are already tired from doing the program.

As mentioned before, there were also some examples of negative attitudes, like the perception of a scientist as someone who has to travel a lot, has little variety in their work, and needs a lot of patience. However, this does not necessarily mean to eliminate all aspects that elicit negative attitudes towards science, since that could create a false image of a scientist. Instead, it shows that scientists might be portrayed in a too specialized manner. While the scientists in this program might travel a lot, it is not like every scientist needs to do that. The same can be said for the lack of variety and the patience. A possible solution is to add examples of more generalist scientists as well. In a qualitative study by Sharkawy (2012), it was found that presenting stories to primary school students about scientists allowed students to perceive scientists less often from a dominant socio-cultural background, and allowed them to perceive the work of scientists less activity-oriented and more inclusive of cognitive and positive affective dimensions. Even though that study was with primary school students, stories could be easily adapted to be appropriate for secondary school students. Especially at Naturalis, this would be very accessible to implement, since there are already lots of scientists working there, meaning there are lots of stories to tell. The stories could include that scientists work in teams, and not only with other academic people, but with people with a wide range of professions and skills. Especially since the target audience of this program is not limited to students with a pre-university background, it would be more inclusive to include other professions as well.

Despite the contextual specificity of the advice above, the five mechanisms that were found should not be dismissed as inapplicable to other settings. While it might not be sensible to include all five themes in every program from one museum (that would decrease the variety too much), it is worth considering implementing one program in each science- or natural history museum, specifically tailored to foster positive attitudes towards science. This would mean developing a program with (1) a diverse research field, (2) real scientists who travel, discover, and know a lot, (3), a focus on understanding science, (4) active learning activities, and (5) exposure to science by the environment, i.e., exhibition rooms. And for museums that already have similar programs, the mechanisms can be used as an evaluative framework, to assess the presence of all five mechanisms.

Future research

Even though the results from this study can extend to other settings as well, it is imperative to recognize that the list of mechanisms provided might not be complete yet, since it is based on one educational program only. For future research, it would be valuable to compare the results from this study with results from other museum programs as well. Additionally, future studies could then choose to include the constructs of ‘motivation towards science’ and ‘attitudes of peers and friends towards science’, to find out whether those have a significant contribution.

By studying attitudes towards science in other programs, and with other subconstructs, the list of mechanisms would expand. This would equip Naturalis, and other similar museums, with a complete framework on how to develop and evaluate their programs to foster positive attitudes towards science. When such a framework exists, it would be useful to also conduct large quantitative evaluation studies. This way, museums can test whether any adaptations made using the framework cause sizable effects on students' attitudes towards science. If that would be the case, museums will play a large role in inspiring young people to follow their interests in science, in a world filled with scientific complexities.

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***Word count**: 7513, excluding references and appendices.*

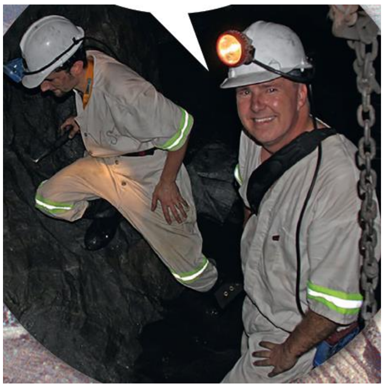
APPENDIX A – OVERVIEW OF THE PROGRAM

The quotes and pictures in Table 5 below are copied from the program material from ‘How do you find out?’ and translated from Dutch to English.

Table 5. Full overview of the three constructs of attitude towards science in the museum program ‘How do you find out?’

Part one: introductory presentation (20 min)	*Quote from the script*	*Attitude towards science construct*
	"Collecting in the most remote places on Earth; being an earth scientist can be hard.”	Perception of the scientist
	"This is how we learn more about Earth's present, past and future."	Value of science
	"How many euros do you think this stone is worth?"	Value of science
	"Which of these two discoveries from the earth has the most value? (...) Why do you think this one is the most valuable?"	Value of science
	“You will be face to face with the most beautiful natural treasures in our museum.”	Enjoyment of science
	“This is without a doubt one of the highlights of our mineral collection. This green crystal is a stunning tourmaline of no less than 25 centimeters, that has been fused with a beautiful quartz crystal.”	Enjoyment of science
	"Minerals can also have an economic value, as resources. What do we use them for? What is the value of the earth?"	Value of science
	"The value of treasures from the earth cannot always be expressed in money. At Naturalis, we are particularly interested in the scientific value of the earth. What do we learn from it?"	Value of science
	“This largest collection of bones of woolly mammoths is also of great value to science. Ice age fossils show how climate has changed over time. They also help glaciologists predict the climate of the future."	Value of science
	"But we also collect lava. What do we learn from that? Who can think of what information researchers get from lava? What is the value of lava?"	Value of science

Part two: program in five exhibitions (90 min)	*Quotes from the booklet*	*Attitude towards science construct*
Exhibition Ice Age	"A glaciologist studies ice and glaciers to find out the climate of the past and predict the climate of the future." 	Perception of the scientist
Exhibition Earth	"A volcanologist studies volcanoes, lava and eruptions. In this way, a volcanologist tries to predict when a volcano will erupt and what the consequences will be." 	Perception of the scientist
	"It is helpful if a scientist speaks many languages.”	Perception of the scientist
	"A mineralogist studies minerals and how they are formed. A mineralogist provides information to jewelers, museums, or customers with gemstones. Sometimes a mineralogist visits a mine or other site themselves.	Perception of the scientist

		
	"Which mineral in the mine do you think would be worst if it ever ran out? Explain why!"	Value of science
	"Get a set of minerals from the Question Cabinet in exhibition Earth. Examine their characteristics".	Perception of the scientist
Exhbition Dinosaur Age	"A paleontologist studies the remains of early life that occurred on land, in the sea or in the air. In this way, a paleontologist tries to understand how life on Earth has changed over time."	Perception of the scientist
		
	"Dutch physician and paleontologist Eugène Dubois (1858-1940) made his world-famous discovery in Java in 1891."	Perception of the scientist
Personality test	Various questions about personal preferences related to the work of the four different earth scientists.	Enjoyment of science
Backside of the booklet	"In order to know what to preserve in terms of natural resources, we must first know exactly what is out there. Our researcher-collectors are surveying nature worldwide. Our vast collection and treasury of natural history data form the basis for research on natural resources in the past, present and future. Now more important than ever."	Value of science

APPENDIX B – RESEARCH PROJECT PLANNING

This research project was conducted as part of the master program Science Education and Communication at Utrecht University. The project consisted of a total of 30 points in the European Credit Transfer and Accumulation System (ECTS), which translates to 840 hours in total. More details on the planning of this research project are depicted below in Table 6.

Table 6. Research planning Gantt chart.

	Nov ‘22	*Dec ‘22*	*Jan ‘23*	*Feb ‘23*	*Mar ‘23*	*Apr ‘23*	*May ‘23*	*Jun ‘23*	*Jul ‘23*
	13 h/w			*27 h/w*			*40 h/w*		
Preparing & designing study									
Writing research outline									
Conducting focus groups									
Transcribing focus groups									
Coding focus groups									
Analyzing focus groups									
Writing research report									

APPENDIX C - INTERVIEW PROTOCOL

Since the focus group interviews were with Dutch students, the interview protocol below is provided in Dutch.

1. Vraag toestemming om op te nemen
2. Introducerend stuk:

Mijn naam is Amy, en ik studeer op Universiteit Utrecht. Hoe heten jullie, en in welke klas zitten jullie? […] Ik zal jullie straks wat vragen stellen over het zaalprogramma wat jullie net hebben gedaan. Dit is omdat ik benieuwd ben wat jullie van het programma vonden, en dan vooral over de dingen die over wetenschap en wetenschappers gingen. Jullie antwoorden worden **anoniem** verwerkt, en de opname zal met niemand anders worden gedeeld. Dit interview duurt ongeveer **15 minuten**, maar als jullie eerder willen stoppen dan mogen jullie dat altijd aangeven. Willen jullie nog steeds meedoen? […] Nog 1x voor de zekerheid: vinden jullie het goed dat dit wordt opgenomen? […]

Openingsvragen

1. Wat vond je van het programma?
2. Wat is volgens jou wetenschap?

Eventuele toelichting over wetenschap: "Ik ga het in de komende vragen specifiek hebben over bètawetenschap. Dat gaat over het bestuderen van de natuur, zoals dieren, planten, stenen, of sterren. Dat kan dus gaan over hele kleine dingen gaan, zoals moleculen, maar ook over hele grote dingen, zoals het heelal. Zo lang het maar met de natuur te maken heeft."

(de volgende vragen hoeven niet in deze volgorde gesteld te worden)

Value of science

- Ben je door dit programma wetenschap belangrijker gaan vinden?
  - Hoe kwam dat?
  - Of: Hoe zorgde het programma daarvoor?

Enjoyment of science

- Ben je door dit programma wetenschap leuker gaan vinden?
  - Hoe kwam dat?
  - Of: Hoe zorgde het programma daarvoor?

- Wat lijkt jou leuk, of niet leuk aan het werk van een aardwetenschapper?
  - Eventueel extra toelichting: een aardwetenschapper is bijvoorbeeld een vulkanoloog / glacioloog / mineraloog / paleontoloog

Perception of the scientist

- Welke nieuwe dingen heb je in dit programma geleerd over wetenschappers?
  - Wat wist je al over wetenschappers?

Afsluitende vragen

1. Wat wil je nog meer kwijt over het programma?
2. Wat wil je nog meer kwijt over wetenschap in het algemeen?