How can narrative reflection facilitate science learning in a museum setting?

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Index

INDEX 1

ABSTRACT 2

INTRODUCTION 3

THEORETICAL BACKGROUND 4

METHOD 13

PARTICIPANTS 13
MATERIALS AND TASKS 14
DATA COLLECTION 18
PROCEDURE 19
DATA ANALYSIS 19

RESULT 21

CONNECTING DAILY LIFE AND VISITING EXPERIENCE 21
LEARNING THE SCIENTIFIC THEORY BEHIND THE EXHIBIT 23
LEARNING BY CONVERSATION AND INTERACTION WITH EACH OTHER 25
OTHER: THE VALUE OF THIS ACTIVITY 27

DISCUSSION AND CONCLUSION 29

SMALL CHANGE OF THE PERCEPTION OF RELEVANCE BETWEEN SCIENCE AND DAILY LIFE 29
LEANING OUTCOMES FROM THE ACTIVITY 30
COMPARISON WITH THE NARRATIVE REFLECTION IN CHICAGO CHILDREN MUSEUM (HADEN, ET AL. 2014) 31
THE BENEFIT FOR NEMO FROM THE NARRATIVE REFLECTION ACTIVITY 33
LIMITATIONS AND FUTURE RESEARCH 33

REFERENCES 35

APPENDIX 1: EXPERIMENT SETTING 38

APPENDIX 2: INTERVIEW QUESTIONS (WITH TRANSLATION) 40

Abstract

The aim of this research is to investigate how narrative reflection, which is possible to extend learning processes by reflecting and narrating the experience, facilitates science learning in a museum setting. Narrative reflection is an approach of sharing experiences through conversations with others. The research was conducted in NEMO science museum, with a newly designed narrative reflection activity. In total, nine families took part in this research. The results were analyzed from the recorded videos during the activity and interview afterward. The results showed that the improvement of perceiving relevance was not obvious, which might be caused by the bias of the participants who had already highly perceived relevance of science. Moreover, the participants had learned science by being aware of the principles lying behind those exhibits. Compared to earlier research about narrative reflection, adding verbal instruction may improve learning efficacy. Additionally, this narrative reflection activity brought a new approach to teaching daily science for many parents in the research. Bigger scale research with a digital narrative reflection is recommended for future research.

Introduction

Since the scientific revolution in the 17th century, human society has seen exponential development. Nowadays, science has permeated in our lives Therefore, the purpose of learning science is not only producing qualified scientists to keep developing our society, but also to raise general awareness about science to the public. Thus, science education is a crucial element for both societal development and public awareness.

Science education can be divided into formal education and informal education. Formal science education is compulsory, teacher-led, and conducted in formal institutions; for example, school science. In contrast, informal education is voluntary, learner-led, and not in a formal setting; for example, a science museum (Wellington, 1990). Formal education is important in that it provides more structured and sequenced knowledge to students (Wellington, 1990), but informal education is also crucial in improving scientific literacy. In this seemed well-coordinated science educational systems in general, however, there are some problems which may attribute the restriction towards the desired goals.

Research suggests that students have less interest in science, because they perceive school science as less relevant to daily life (Osborne, Simon, & Collins, 2003; Schreiner & Sjøberg, 2007). The research from Osborne et al (2003) indicated that students from the UK found it difficult to perceive the relevance of sciences, especially physics and chemistry, to their daily lives. Because of this, it is likely that these students will have less of interest towards science, consequently leading to a situation that fewer students choose science as their career fields, and moreover, the general public will be less aware of scientific issues because they could not be inspired during their students' lives.

Apart from formal education, informal education also plays an important role to compensate the insufficiency from informal education in the whole educational system. Falk & Dierking

(2010) indicated that people only spend 5% of their lifetime in formal schools. The best way to improve public understanding of science is to reach them in the rest 95% of their life by informal education. Therefore, there are many possibilities and chances to change attitudes and behavior from informal educational institutes. Because of the many possibilities of conducting informal education, this research will mainly focus on informal education in a science museum.

Science museums seem proper places for children to learn science, because their hands-on exhibits are fun, attractive, and there are no pressures of memorizing and studying from parents and teachers. However, it is unclear what the actual learning outcomes from science museums are. In the research from Allen (2004), she indicated that learning science in science museums is actually very difficult. The visitors have complete freedom to follow their impulses and interests to enjoy the exhibition because there is no enforcement on concentration by teachers or parents. Moreover, there is no guide to give significant meaning or theory behind the exhibits to the visitors. Even there are some descriptions about the exhibits next to them, the visitors will have no obligation to read through all this important information, therefore, the learning outcome is actually limited. Therefore, developing a more efficient strategy in science museums is crucial for improving science learning and the following problems.

Theoretical background

Science museums in informal education

In science education, formal education and informal education have different characteristics, play different roles, and additionally, collaborate in the process of science learning. In formal education, students learn solid theories and methods of science with structured and sequenced curriculum in schools. The learning intention of students is not the most important factor in formal education, because it is compulsory and teacher-led (Wellington, 1990). Whereas, in informal education, students voluntarily learn and experience science outside of schools by themselves. Even though the contents of science in informal education are not as organized as what formal education provides, it can inspire students to gain interest to investigate science deeper (Sasson, 2014). Despite formal education and informal education are almost conversely different, they collaborate well with the science education system. For students. while formal education provides knowledge to them, informal education generates intention of learning science. Informal education provides "a place within which the very different and competing discourses of the school system and the everyday world are reconciled" (Stocklmayer, Rennie, & Gilbert. 2010, p26). It makes opportunities for students to see the meaning of what they have learned before by linking their daily experiences and knowledge (Ayres & Melear,1998), and gives the motivation to keep learning. For adults, informal education gives chances to keep in touch with science and new technology, so that they can gain new perspectives instead of being dissociated from the current world.

Informal education can be presented in science museums, zoos, and outdoor settings; science youth programs; science media, etc. (Hofstein & Rosenfeld, 1996). In the current research, science museum is the main focus. Science museum is a relatively broader concept because people learn in different ways in different science museums based on the museum settings. According to Smit (2012), science museums can be divided into four types by two factors: "how do people learn?" (learning theory) and "what is knowledge?" (theory of knowledge) (See **Figure 1**). The first type of science museum is the traditional didactical museum (corresponding to "traditional lectures and text"), which try to "teach" visitors by giving lectures or posing texts with solid knowledge. The second is behavioral school (corresponding to "behaviorist learning"). The difference between the traditional didactical museum and behavioral school is that visitors in behavioral schools have to shape the knowledge they have learned at the end of the tour by reinforcements. The third type is the science center (corresponding to "discovery learning"). Science centers show the reality to visitors and let them discover by themselves. The last one is the constructivist museum (corresponding to "constructivism"). Constructivist museums provide multiple theories or perspectives toward one fact, and let visitors gain their own answers or perspectives.

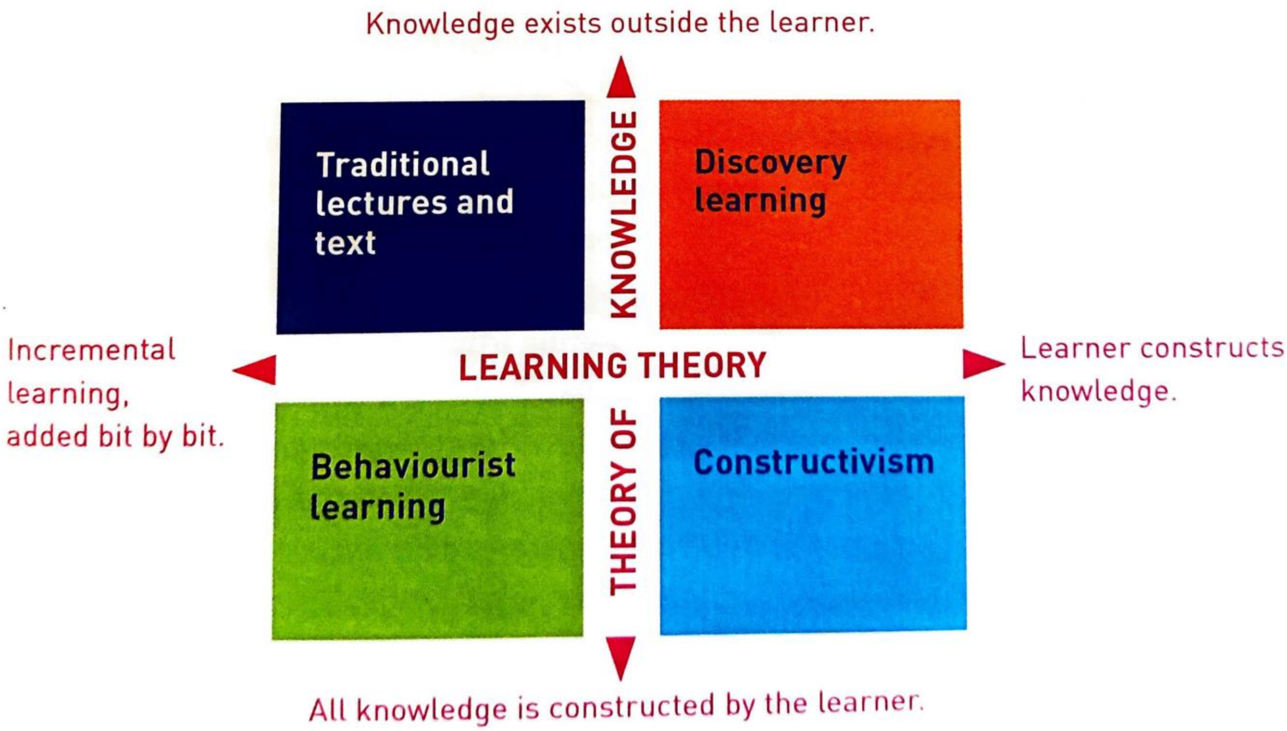

Figure 1. Four types of science museums according to learning theory and theory of knowledge. (Smit, 2012, p. 21)

The current research was taken in NEMO Science Museum, which is located in Amsterdam, the Netherlands, is one of the biggest science museums in the Netherlands. As a science museum, they hope visitors can learn science by doing, and by experiencing with their senses through hands-on exhibits (NEMO, 2019). According to **Figure 1**, NEMO is classified as a science center, which demonstrates reality to the visitors while visitors learn and discover during their visit. Therefore, visitors can do experiments by plenty of hands-on exhibitions to see scientific phenomenon in reality while learning about science at the same time (Raijmakers, 2012).

Narrative reflection

Haden, Cohen, Uttal, & Marcus (2015) defined that "narrative reflection is the telling and sharing of experiences through conversations with others" (Haden et al., 2015, p. 87). Visitors can re-think and remember the visiting experience from the museum through stepping back and reflecting by verbal expression. Narrative reflection may enhance learning, because it can be part of the learning process, and provide possibilities for extended encoding after the actual activity (Haden et al., 2015). In other words, visitors may learn new things after they share their experiences with others; and this part of learning does not happen during the activity, but after the activity. The theoretical background of narrative reflection includes different fields, such as psychology, education, and learning science, etc. In the sociocultural theory's regards, how children understand their experiences can be changed by the process of children talking to adults about their experience, because the language allows for new forms of thought (Haden et al., 2015).

In Chicago children's museum (CCM) in the USA, narrative reflection has already been implemented in a museum's context (Haden et al., 2015). One of the exhibits from CCM that inhibits narrative reflection is the Skyline.; an exhibit about building and engineering. In this exhibit, visitors joined the activity called Skyscraper Challenge as a family. During the activity, they had to build the tallest and most stable building within a time limit, also there were multiple cameras and microphones to record their conversation and interaction. After they finished building, families were promoted to join the reflection section. In this section, families sat in front of a computer kiosk, where they had to select six photos of themselves that where taken during the activity. After that, they were prompted to tell personal reflective narratives regarding their experiences.

This type of narrative reflection is called ‘photo narrative’, in which people see a photo and talk about the visiting experience related to the photos (Haden et al. 2015). Haden and her colleagues had experimented three types of narratives in her researches, photo narrative was one of them. Photo narrative, which has been proved as an effective approach by their previous study, is a “valuable way to access some of what children took away from their building interactions with their parents in a manner that was a part-and-parcel of the museum exhibit experience” (Haden et al. 2015, p. 97). Before photo narrative was added in the study, the research team had conducted few studies to try different types of narrative reflection. The second type was called ‘reunion narrative’. The idea came from what people naturally do in museums: “split up for a period of time, and then get back together and talk about what they have experienced while apart” (Haden et al. 2015, p. 92). In this prior study, each child built the building with an adult partner, and reflecting the experience by asked open questions from another adult. The third type was called ‘memory narrative’. The research team invited participants to make an audio record at home after they visited the museum. By memory reflection, researchers can study what the participants had remembered, and how they elaborated their visiting experiences.

Relevance of science

Science is everywhere in our daily lives; and the goal of learning science is to help learners improving their lives in the future. Since the 20th century, the aim of science education has already focused on the relevance of our contemporary lives (DeBoer, 2000). No matter the better understanding about the world surrounding us, the preparation for working in the future, or training students to become responsible citizen, actually, the goals of learning science are always related to our lives. DeBoer (2000) listed nine goals of science education: (1) learning about science as a cultural force in the modern world; (2) preparation for the world of work; (3) learning about science that has direct application to everyday living; (4) teaching students to be informed citizens; (5) learning about science as a particular way of examining the natural world; (6) understanding reports and discussions of science that appear in the popular media; (7) learning about science for its aesthetic appeal; (8) preparing citizens who are sympathetic to science; (9) understanding the nature and importance of technology and the relationship between technology and science. However, students nowadays still have difficulties to perceive the relevance of science although science educators have aimed to reach these goals in decades. The research from Osborne et al. (2003) investigated what the attitudes toward science were from students. In that research, students stated that they did not need to know the difficult equations and periodic table from chemistry class in their lives, because they failed to perceive the relevance of science to their daily lives, which means the failure of the third goal from DeBoer (2000). Therefore, in the current research, the "relevance of science" is narrowed down toward the third goal from DeBoer (2000).

Stuckey, Hofstein, Mamlok-Naaman, & Eilks (2013) investigated how students would feel learning science is related to themselves. They listed 3 main dimensions of relevance, which were also included by the categories from DeBoer (2000):

1. Relevance for preparing students for potential careers in science and engineering;
2. Relevance for understanding scientific phenomena and coping with the challenges in a learner's life; and
3. Relevance for students becoming effective future citizens in the society in which they live. (Stuckey et al. 2013, p. 9)

Based on their definition, **Figure 2** displays the examples of relevance in 3 dimensions with 2 other factors: time (past and future) and motivation (intrinsic or extrinsic). In the current research, the relevance of science in individual and societal aspects will be investigated based on the problem addressed by Osborne et al. (2003) which has been mentioned in the previous paragraph.

To improve relevance in science education, Stuckey et al. (2013) named some motivations for students to learn science in different dimensions (see **Figure 2**). For example, encouraging students to learn science to prepare skills in order to cope with their personal lives in the future belongs to the individual dimension. Learning how to behave in society is part of the social dimension.

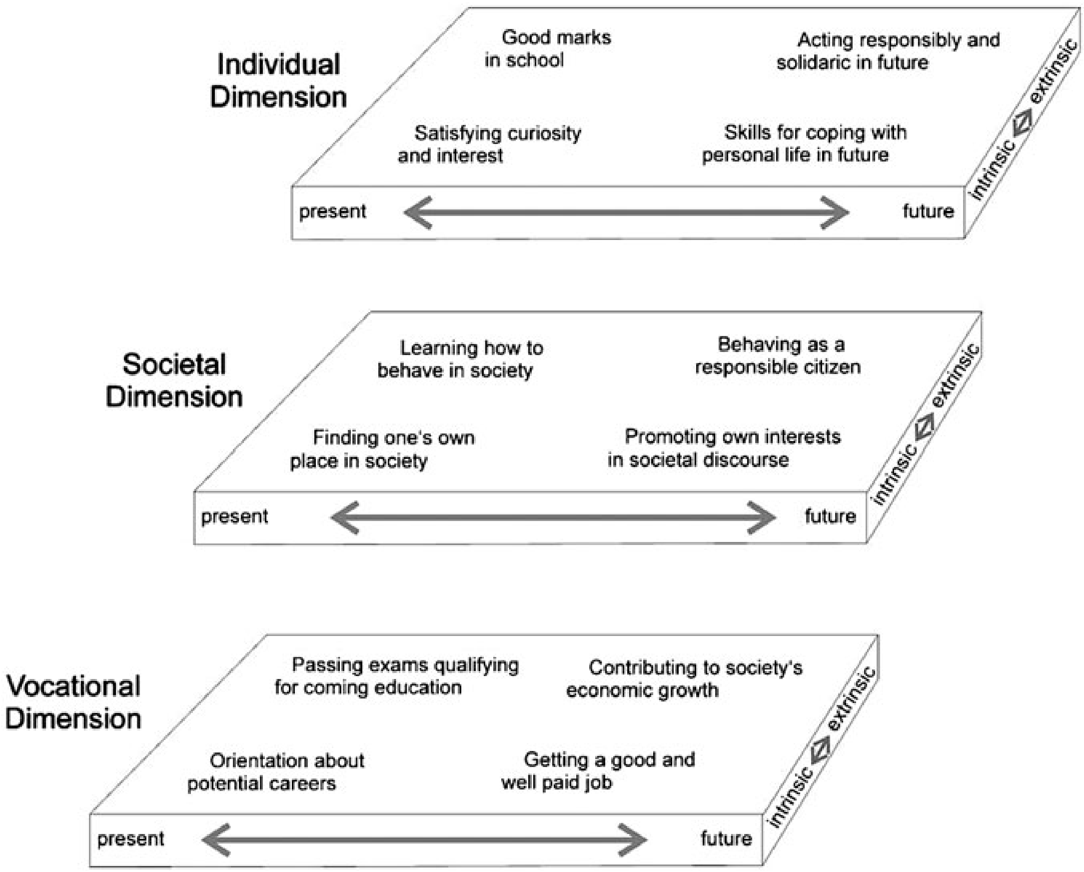

Figure 2. The model of relevance with 3 dimensions with time axis (past-future) and motivation axis (intrinsic-extrinsic). (Stuckey et al., 2013)

De Jong (2006) gave some suggestion to enhance the perception of the relevance of science as well. In context-based teaching, the contexts can provide students motivation to learn science with vivid situations and examples in real life. De Jong (2006) classified the contexts into four domains: (1) personal domain; (2) social and society domain; (3) professional domain; and (4) scientific and technological domain. To be more precise, the contexts in the personal domain can use many issues and examples from daily life. By adding contexts, for instance, the examples of clothes and material while teaching chemical properties and structure, the interests of students of learning science could be stimulated (De Jong, 2006).

The current research tries to implement narrative reflection to facilitate science learning in NEMO Science Museum. Considering the problems mentioned in the previous paragraphs; insufficient perception of the relevance of science and insufficient learning outcome in science museums, the research questions are as follows:

1. How does narrative reflection facilitate the perception of the relevance of science to visitors?
2. How does narrative reflection improve learning outcomes in the theoretical aspect?
3. How does the conversation in narrative reflection facilitate learning from other family members?

To improve the perception of relevance toward science and learning outcomes from the visitors in science museums, narrative reflection could be a suitable solution. Narrative reflection can possibly extend learning processes by reflecting and narrating the experience. Visitors re-think about what has happened during visiting exhibits, acquiring an extra chance to learn by their own experiences and others' experiences as well. In this research, the activity is designed by using a combination of photo narrative and memory narrative methods. The reunion narrative was not considered because of possible difficulties that may have aroused if the participating groups were asked to visit the museum separately, since there was no present isolated exhibition area. This means that within this environment there is no reliable way to control if people would have interacted during their visit to the museum. Using the reunion narrative in an open museum environment could therefore negatively influence the quality of the experiment. Moreover, the personal context factor will also be taken into account in the research design to enhance the perception of the relevance of science from visitors with daily examples, consequently, enhancing their attitudes toward science.

Method

This research is an exploratory study with a newly designed narrative reflection activity. In this section, the details of the experiment and analysis are discussed.

Participants

This research has collected nine families in total. However, the data from one family is excluded due to the low quality of the recording, therefore, eight sets of data are included in this research. Consequently, the used data came from eighteen participants in total, with eight parents and ten children (six families with one parent and one child, two families with one parent and two children). Most of the participants are female, only one parent is male, the other seven are female. In the children's group, the female gender is also in the majority; eight out of ten children are female, and the other two are male. The age of participants is ranged from 36 to 48 years old (parents' group) and six to twelve years old (children's group). Among the eight participating families, there are three Dutch families, one Canadian family, and four Chinese families, and they all live in the Netherlands. The demographic data is displayed in **Table 1.**

Table 1.

The demographic data of the participants.

NO.	Parent					Child			
	Gender	*Age*	*Nationality*	*Educational level*	*Occupation*	*Gender*	*Age*	*School*	*Grade**
1	F	47	Dutch	Bachelor (HBO)	Teacher	M	11	Public	6th
2	M	48	Dutch	Bachelor (MTS, MBO)	Website analyzer, programmer	F	11	Public	6th
3	F	44	Canadian	PhD	Teacher, professor	F	9	International school	4th
						F	7	International school	1st
4	F	47	Dutch	Bachelor (WO)	Psychologist	F	12	Public	7st
						F	8	Public	3th
6	F	36	Chinese	PhD	housewife	M	6	Public	1st
7	F	40	Chinese	Bachelor	Operation management	F	10	Public	6th
8	F	39	Chinese	Bachelor	Housewife	F	7	Public	2th
9	F	43	Chinese	College	Assistant in the company	F	9	Public	3th

Note. M=male, F=female. *The grades of every child are transformed into the international standard.

To recruit participants, sending invitations via the internet and directly inviting families in NEMO science museum were the main strategies to invite people to join the research. International families have been invited by the internet (i.e., via social network, inviting though international schools) due to a language issue where the researcher cannot speak the local language. In these eight families, five of them joined the research because of the invitation on the internet in advance, others three were invited in NEMO face to face.

Materials and tasks

This narrative reflection activity aims to provide a time for parents and children to talk about their experiences in NEMO science museum and daily life. For instance, what they have seen that day and how they could link their experiences to their daily life. The activity started with choosing the exhibits they wanted to reflect on. They had four options, which were all exhibits on the first floor in NEMO science museum (pulley seats, spinning chair, shadow wall, roll box from “do research like a scientist” series, see **Figure 2**). After participants decided the exhibit, there were four steps of reflection, and relevant materials put in four boxes that were numbered respectively (See **Figure 3**). First, participants were given the opportunity to think about what they had done in this exhibit. After that, they were instructed to express their thoughts by putting magnet stickers with different expressions on them on a whiteboard accordingly. The second step was about reflecting why they like this exhibit. They would think about which part of the exhibit they liked by placing magnet stickers (i.e., hearts, stars) on the whiteboard, also adding a written reason behind their choice on a cartoon balloon. The third step was to fill in the worksheet, which contained three parts: giving the exhibit a name, marking three essential parts in the exhibit, and using these three keywords to describe the exhibit. This step aimed to make participants think about the theory lying behind the exhibit. The final step was asking participants to think about the similar cases they had seen before in daily life, by writing it down on the cartoon balloons. Participants had to think of at least one example and write down the similarities and differences. The material and the experimental setting are shown in **Figure 3** and **Appendix 1.**

a

b

c

d

Figure 2. The exhibits on the first floor of NEMO which included in the experiment. **a**: **Spinning chair** (demonstrating the law of conservation of momentum with wheels and rotatable chair); **b**: **Roll box from "Do Research Like a Scientist" series** (experimenting the different results by asking themselves "What influences the roll time of cylinders: the mass, the diameter or the mass distribution?" with different cylinders); **c**: **Pulley seat** (experimenting with different powers of pulling themselves up with three different pulley-sets); **d**: **Shadow Wall** (demonstrating the phosphorescent by flash, light-storable wall and the shadow from visitors).

Figure 3. The experiment setting in NEMO R&D room.

Since there were plenty of nationalities involved in this research, there were different languages which were used in the activity. The activity was basically conducted in English, including an English introduction, English description, English worksheet, and English interview. However, apart from FAMILY 3 (where the entire activity was conducted in English), there were few other languages involved during the activity and interview. For Dutch families (number 1, 2 and 4), the children's English ability was not sufficient to do this kind of narrative activity. Therefore, most of the parents helped to translate the information from English to Dutch, and the conversation and interview were conducted in Dutch. For Chinese families, apart from the descriptions and worksheet in the boxes that were conducted in English, all the conversations and interviews were spoken in Chinese, because the researcher is a native Chinese speaker.

Pilots

Before the final data collection, the activity was pilot tested four times with different parent-child couples than those who participated in the evaluation. From the results of the first two pilots, the supporting materials (i.e., stickers) were added in the activity, because participants showed some difficulties to reflect their experiences without receiving any visual hint to structure their thoughts. Therefore, to facilitate the reflection, the activity has been set in four steps with a clear introduction, explicit task and supporting materials. However, the pilot results also showed that the participants would distract by too many materials on the table. In these cases, the participant would not be able to follow all the necessary steps in the right order. Thus, the final pilot showed that this could be solved by putting materials in four corresponding boxes.

Data collection

To study the results from the activity, there were three types of data which were used in this research: conversation during the activity (video-recorded), the semi-structural post-interview (video-recorded), and the background information (video-recorded). All the data was recorded to video and transcribed into words to be analyzed afterward.

The post-interview contained four questions (See **Appendix 2**), with some following questions to clarify previously made statements. The first question in the interview was "What do you think about the activity you have just done?", which aimed to ask how the participants value the activity. The next question was about what they had learned in the activity. The third was asking about what they thought about the connection between daily life and science, and if their thoughts had been changed by the activity. The final question was to see how the activity influenced the interaction in the family's members after they had left the museum.

After the four main interview questions, we administered a basic demographic survey. It included age, gender, nationality, educational level (parent only), occupation (parent only) and type of school (child only). (See **Table 1**)

Procedure

The whole activity took around 30 to 40 minutes, including the introduction and the final interview. After the participants came into the Research and Development room (R&D room) in NEMO science museum, which was the room this research took place, they would have a short introduction about the procedure of the activity, so they had better knowledge of what they were going to do in the coming 30 minutes. Before starting the activity, parents would be asked to sign a video recording consent as a requirement to partake in the research. Within this consent, participants were given several choices regarding their privacy related to the video material. After the activity, there was a short interview with four main open questions, and some questions regarding background information. In the interview phase, participants were interviewed separately. child(ren) first, and parent(s) last.

Data analysis

The videos which were taken during activities and interviews have been transcribed into transcripts. For the Dutch families, the videos were transcribed by a local Dutch person into English. For the Chinese families, the videos were transcribed by the researcher, who is a native Chinese speaker, into Chinese transcripts first and translated into English afterward.

The data was open coded by marking research-question-related sentences from transcripts or behaviors from videos. The coding scheme is based on the three research questions and others, which are unexpected findings. Those research-question-related conversations and behaviors were marked and categorized in four groups: (1) connecting daily life and visiting experience; (2) learning the scientific theory behind the exhibit; (3) learning by conversation and interaction with each other; and (4) other. In each group, all the sentences and behavior have been analyzed the intention behind from the words they used and their body language. Next, these results from group 1, 2 and 4 were divided into few sub-groups (codes) based on the similarity of their statements and attitude. For group 3, the codes were not about their statements or attitudes, but about the types of guidance, because we wanted to know how participants learned from each other. The codes in all groups are presented as following:

1. **Connecting daily life and visiting experience**: did not change, became more aware of, did not understand the question (or did not know).
2. **Learning the scientific theory behind the exhibit**: did not learn new things, noticed the theory behind the exhibit, notice the relevance of the exhibit.
3. **Learning by conversation and interaction with each other**: ask open questions, give hints, directly give examples.
4. **Other (The value of this activity)**: did not value it, it was fun, it had educational value.

Result

Results are analyzed based on the transcripts of conversations from the activities and interviews. The transcripts were coded according to the three research questions. A fourth category has been added describing how participants valued this narrative reflection activity.

Connecting daily life and visiting experience

Generally speaking, this activity cannot significantly improve the perception of the connection between science and daily life. **Table 2** displays the categorized response from the participants.

Table 2.

The result of research question 1: How does the narrative reflection facilitate the perception of the relevance of science to the visitors? The answers from the interviews and the reaction during the activity have been coded and categorized into three results: the attitude did not change, the participants became more aware of this, or the participants did not understand the question.

Codes	*1*	*2*	*3*	*4*	*6*	*7*	*8*	*9*	*Total*
Did not change	p c	p	p	p	p c	p c			p=6/8 c=3/10
Became more aware of		c		c c			p	p	p=2/8 c=3/10
Did not understand the question (or did not know)			c c				c	c	p=0/8 c=4/10

Note. p=parent, c=child

Half of the participants (nine participants) claimed in the interviews that they already highly perceived the connection between science and daily life, and this attitude did not change after the activity. The majority of parents tended to have this attitude. Six out of eight parents claimed the perception had remained. For example, the parent from FAMILY 2:

Researcher: In your opinion, how does science relate to your life

Parent: Always, everywhere, everything is connected

Researcher: Does this activity give you any influence on your attitude

Parent: No

However, five participants were more aware of the connection. Three of them are children, which all claimed that after this activity, they became to think more about the happening and surrounding environment. For example, the younger child in FAMILY 4:

Researcher: What kind of influence you have…?

Younger child: Because you know how things work now.

Parent: Yeah, and what is it about? If you know how things work, how will you act differently or look at things differently?

Younger child: Look at things differently.

She indicated that after the activity, she perceived the complicated mechanism behind the exhibit, even she did not understand what the mechanism exactly was, but she started to look at things differently.

Two of the parents who became more aware of the connection of the activity between science and daily life explained their improvement. Both of them claimed that they already found that this connection was strong. But after the activity, they felt the connection became stronger by seeing the real example and realized the fact by heart. An example from the interview from FAMILY 8:

Parent: I already think about it. It is just I might... I know that science and life are very relevant. It may not be on the conscious level, but now I am more aware of it on an unconscious level.

The rest of the four participants (all children) did not answer the question. Two of them were from the same family. They answered: "*I don't know*" toward the question "in your opinion, how is science-related toward your life?". However, based on the observation and interpretation from the researcher, their parent showed that her daughters knew that science is related to our lives, but science is everywhere, therefore they cannot distinguish or recognize like this way. As for the other two participants, they did not only claim that they did not know how science is related to daily life, but also showed that they did not know what science is in the interviews. Because they did not understand the keyword: 'science' in the question, it is hard to distinguish if they perceived science was related to daily life.

Learning the scientific theory behind the exhibit

Table 3 shows the results of whether the participants learned the theoretical facts of the exhibits during the activity.

Table 3.

The result of research question 2: How does the narrative reflection improve the learning outcome in the theoretical aspect? The answers from the interviews has been coded and categorized in to three results: the participants who did not learn anything, the participants who noticed something they did not notice before which was related to the theory behind the exhibit, or the participants who noticed something they did not notice before which was related to the relevance of science and daily life.

Codes	*1*	*2*	*3*	*4*	*6*	*7*	*8*	*9*	*Total*
Did not learn new things	p c	p	p c	p	p	p c	p c	p	p=8/8 c=4/10
Noticed the theory behind the exhibit		c	c	c c					p=0/8 c=4/10
Notice the relevance of the exhibit					c			c	p=0/8 c=2/10

Note. p=parent, c=child.

Two-thirds of the participants claimed that they did not learn theoretical facts from the activity. Interestingly, all of the parents said they did not learn new things from the activity, only some children expressed they had noticed something new during the activity. Many parents claimed that they had already learned these theories about physics before, therefore, they already knew what the exhibits were about. The example below is from FAMILY 7:

Researcher: Do you learn anything about science?

Parent: This scientific knowledge is enough for me, so I just want to guide

For those children who did not learn new things, the reasons were different than those from the adults. The child from FAMILY 7, did not learn something new during the activity, because she already had learned that when she was doing the exhibit (before the activity). Moreover, the child from FAMILY 8 did not really learn new and meaningful things, because she could not follow the activity. In the interview, the mother was trying hard to guide her through the whole activity, hinting her that she knew cranes were similar to the pulley seat. However, she only understood that she learned the fact that cranes were similar to the pulley seat, but could not extend the example to the broader world. Therefore, she did not learn theoretical facts, and also did not notice the relevance of science and daily life.

Regarding the four children who had noticed part of the theory behind the exhibit, they presented similar answers to this question. Even when they did not learn the whole physic theory behind the exhibits, they claimed that they had noticed either the key components (FAMILY 2, 3), or the complicated mechanism behind it (FAMILY 4). Even when they had been told by others about the key components or mechanism, they understood these facts better after the activity (see the example from FAMILY 2 below).

Researcher: Did you discover something new while doing this activity?

Child: I knew that the pulleys were important, but so important that you could pull yourself *up not using a lot of strength. I did not know that, but I do know now*

Researcher: So, this is while you're doing the exhibit and you experienced it or you're doing this activity and you noticed this

Child: Because of this activity, I started thinking more about it more and I understood it better

There were two children who learned the relevance of science and daily life during the activity. In the interviews, both of them expressed that they learned the exhibits implemented in other places but with some differences. Therefore, instead of theoretical facts, they learned the relevance of science and daily life.

Learning by conversation and interaction with each other

According to the conversations during the activities, learning from family members happened in every participating family. In all families, children received guidance and new information about science from the parents' side. Some of the parents in the interviews stated that they had "learned" more about their children (i.e. cognitive performances and talents) than they have learned about science. However, the parent from FAMILY 3 found out new ways to communicate with her young children by observing the performance and behavior of her children during the activity.

Researcher: Did you learn something from this activity?

Parent: Uhm…. not really something new, but just how important to be able to communicate those stuffs (the exhibit) …. it a way to communicate them…. So, for this age of group, probably use pictures or figures is better a way for them to communicate, like having them to write down everything.

Most of the parents guided their children with open questions first, and then giving hints, but sometimes they would also directly give answers or examples if found necessary. The number of times guidance occurred when children showed confusion during the activity (only in box 3 and 4, which were questions that required more thinking compared to box 1 and 2) are shown in **Table 4**. There were three types of guidance: (1) ask open questions: parents asked WH questions about the given subject and let the child think about it; (2) giving hints: parents provided some information first and let children think (i.e., yes-no questions, filling blanks, reminding the thing they had been told before, etc); (3) directly give answers or examples: parents did not let children reach the final answer by themselves, but directly gave examples or answers.

Table 4.

The times of guidance when children showed confusion during the conversation during the activity (Box 3 and 4). The guidance was divided into three types: (1) ask open questions: parents asked WH questions about the given subject and let the child think about it; (2) giving hints: parents provided some information first and let children think (i.e., yes-no questions, filling blanks, reminding the thing they had been told before, etc); (3) directly give answers or examples: parents did not let children reach the final answer by themselves, but directly gave examples or answers.

Codes	*1*	*2*	*3*	*4*	*6*	*7*	*8*	*9*
Ask open questions	1	1	1	2	4	1	7	1
Give hints		1	2		4	1	12	3
Directly give examples	1				1	1	4	2

Table 4 suggests that asking open questions was the most common way of guidance, and fewer parents would directly give examples or answers. The number of guidance was ranged from two to 23. The parent from FAMILY 8 guided more in comparison to parents from other families, because the child could not follow the activity and did not understand the situation.

Apart from this, in each family, the guidance happened from two to five times, which means the children felt confused and needed help from two to five times. Interestingly, according to **Table 4**, every family gave guidance during the activity, but the amount was different. FAMILY 1 to 4 were families from western culture (Dutch and Canadian), and FAMILY 6 to 9 were all Chinese families. Parents from Western cultural families gave less guidance (two to three times), while Chinese parents gave from three to 23 times of guidance during the box 3 and 4.

Other: The value of this activity

In the interview, few questions aimed to investigate other potential effects and possibilities regarding the activity by investigating how participants valued the activity. **Table 5** shows that half of the participants had seen the educational value from the activity, and almost 40 percent of the participants liked it just because it was fun. Only two participants (from the same family) said they would not do it again.

Table 5.

The value of the activity for participants. Based on the interview, their answers were coded and divided into three types: (1) they did not see the value from this activity, they would not do it again in the future; (2) they would like to do it again because it was a fun activity for them; (3) they would like to do it again because they thought they or their children would learn more through this activity.

Codes	*1*	*2*	*3*	*4*	*6*	*7*	*8*	*9*	*Total*
Did not value it	p c								p=1/8 c=1/10
It was fun		c	c c		c	c	c	c	p=0/8 c=7/10
It had educational value		p	p	p c c	p	p	p	p	p=6/8 c=2/10

Note. p=parent, c=child.

Apart from the first family, almost every parent noticed the educational value from the activity. The parent from FAMILY 2 liked this activity because it showed the connection between science and daily life to them and made them think more about this. In FAMILY 3, the parent valued this activity from another perspective because she learned more how to communicate with her young children by having a chance to observe the performance and behavior from her children during the activity. But the majority opinion (seven out of eight parents) was that this activity can let the children learn more. Moreover, parents from FAMILY 7 and 9 would like to apply this strategy or reflecting structure by themselves outside of the museums, to teach their children about the daily phenomenon surrounding by them. Apart from adults, there were also two children from FAMILY 4 who appreciated the educational value from this activity. The younger child liked that this activity made her notice the connection between science and daily life. The other child liked the fact that it was educational without feeling stressed about whether the answer is correct, because it was an activity only about reflection.

For children, even they also reflected that they actually learned something new during the activity, they did not view this activity as an educational tool like their parents. they could only appreciate the joy they derived from participating in the activity itself. Children from FAMILY 6, 8 and 9 liked this activity because the hands-on factor was fun; such as posting magnets and writing. The child from FAMILY 7 liked it because there were many thinking sections in the activity. Also, there were three children (FAMILY 2 and 3) who just liked it without a specific reason.

Discussion and conclusion

A small change of the perception of relevance between science and daily life

The result of the first research question showed that the perception of the relevance between science and daily life did not significantly improve. Taking into account the educational level of the participants, it is highly possible that the included participants were already more educated in science in comparison to the average person. In the interviews, many participants who said their attitude did not change indicated that they already perceived in this way, and the activity did not make this perception stronger.

Attitude changing is highly related to prior knowledge. Phelan, Specht, Schnotz & Lewalter (2017) indicated in their research about changing the attitude in a museum setting that "attitudes are formed and changed by a mixture of prior knowledge, existing attitude, and the more or less elaborate processing of new information" (p. 874). In their research, their results showed a small change of attitude, which might be caused by a higher level of topic-specific prior knowledge from the participants. Because of better prior knowledge, a change in scientific knowledge would be rather small and possibly not significant. This might be the same case in this research about narrative reflection. During the interviews, the participants showed they have a strong perception of how science is connected in daily life. It is highly possible that the activity did improve prior knowledge of the participants, however, this improvement appeared of no significance and went thus, unnoticed

Among these eighteen participants from eight families, half of them had been to NEMO several times before the experiment. Participants stated they had a "museum card", which is a discount card for visiting all museums in the Netherlands, and had already been to NEMO many times before. This fact indicated that they really liked visiting NEMO and exploring science with their children together before they joined the experiment. Moreover, the participants were recruited either by the researcher directly when they coincidentally visited NEMO, or they voluntary signed up on the internet with the benefit of free entry to NEMO. Therefore, these participants were already interested in visiting NEMO, which is well known as a science educational museum. It is possible that the method of recruiting participants in this research was biased, which caused that there was a higher chance of selecting participants with an already higher-than-average perception of relevance between science and daily life. For those who had a difficulty of perceiving the relevance, it is likely they would neither visit NEMO voluntarily, nor find signing up attractive enough to benefit from free entry to NEMO.

Learning outcomes from the activity

The results indicated that none of the parents in the experiment claimed that they learned something in the activity in the interview, while more than half of the children (six out of ten) thought they might have learned something. The difference between parents and children is likely to be explained from the huge gap of prior knowledge of science. According to the demographic data, all the parents had received higher education, which ranged from a college to a PhD degree. Therefore, it is probable that every one of them has learned about basic physics before entering higher education. This regardless of choice in higher education. The theories behind the exhibits were taught already when they were students.

Based on the results, six of the children who claimed they had learned something new in the activity noticed either the complicated theories behind the exhibits, or relevance of science and daily life. Noticing new things means the children started to be aware of the scientific theory. According to the conditions of learning instructional design theory from Gagne (Shachak, Ophir, & Rubin, 2005), there are nine events in the learning process. The first step of learning is gaining attention, which means noticing or being aware. Therefore, the result of learning scientific theories lying behind the exhibits was partially achieved, even though none of the children had mentioned anything about “real science” such as forces or mechanicals, they have already made their first step in learning science.

Comparison with the Narrative reflection in Chicago Children Museum (Haden, et al. 2014)

This research is inspired by the research from Haden and her colleagues (Haden et al., 2014; Haden et al., 2015), however, the research designs are different. In the research from Haden, et al. (2014), the participants joined the specific exhibit called the Skyscraper Challenge and the narrative reflection section after the exhibit. The variables in their research were the introduction and tips provided during the Skyscraper Challenge. Based on the variables, the participants were divided into four groups: (1) inspector sturdy build + talk introduction, (2) inspector sturdy build introduction only, (3) build + talk sign, (4) no introduction control. “Inspector sturdy build” means that the participants would receive building tips when they were doing the challenge by inspector sturdy who was played by the researcher. The talking introduction contained the additional tips from inspector sturdy to encourage parents asking WH questions (i.e. What? Why? Where? How?) toward their children while they were doing the challenge. For the third group, they did not receive any tips by verbal instruction, but by the static signages which were also used in the first and second groups. In comparison to the research from Haden, et al. (2014), the current research did not intervene while the participants were doing any of the four exhibits, whereas building and talking instructions were given while participants were doing the Sky Challenge exhibit in the Haden, et al. research. However, the reflecting phased after doing the exhibit was remained in the current research.

From these two pieces of research, the shared fact of providing hints or tips is one of the crucial factors of learning outcomes. The photo narrative results from Haden, et al (2014) showed that the families who received tips for building (group 1 and 2), compared to who did not receive any building instruction, talked about more different categories of science, technology, engineering, and mathematics (STEM), especially in children. Moreover, Haden et al (2014) indicated that children who received building instruction seemed to have a better understanding of the building activity in the STEM aspect. In the research which was conducted in NEMO, this similar fact had also been noticed. Some participants showed in the interviews that they had learned new things in step 3 and 4, which are the steps of providing hints of the exhibits' composition and tasks to think about examples in daily life. For example, one of the children in FAMILY 3 mentioned that she noticed that, during the activity, the key components for Pulley seat were a chair, pulleys and a rope which was one of the tasks in step 3. Additionally, the child in FAMILY 6 also claimed that he found out that *"There are many things that can happen with gears (pulley)"* from the interview which came up from thinking the examples in daily life in step 4. These results showed that it is important to give certain hints or guiding the participants if the desired result is improving general science-learning, instead of letting them try exhibits with completed freedom.

However, the result from Haden et al (2014) mentioned that verbal introduction was more effective than static signs. The researchers noticed that even the third group used the same signages as the first and second group, however, they were not able to use the information from signages as efficient as the first and second group; because of the absence of verbal introduction. In the current research, guidance or hints were also only presented by static introduction inside the boxes. Therefore, for future study or implementation, adding verbal introduction by assistants or recorded-videos as tips or hints are recommended.

The benefit for NEMO from the narrative reflection activity

The result of improving the perception of relevance and learning outcomes from this study brings certain benefits to NEMO. According to the NEMO (2019) official website, NEMO wants visitors to learn the basic principle of science by experiencing with their senses, to discover and explore who they are and also the world around them. The activity was enhancing the expected outcomes from NEMO activities in general by providing a chance for visitors to reflect. That is, some participants started to notice the scientific theories behind the exhibits, which was the first step in learning science. Moreover, some participants felt the connection between science and daily life, which is also one of the expectations from NEMO, by joining this activity. In addition, the fact that parents brought an approach of guiding children to think about science in daily life also matches the NEMO's concept of "science is everywhere". Thus, learning science by experiencing will not only happen inside the museum, but also spread out to the entire environment surrounding us.

The conversations from different families provided important information for NEMO about how visitors view these exhibits, and how they interact with the exhibits. By analyzing this data, NEMO can learn from their visitors' behaviors, so they can build or re-form new exhibitions in their future endeavors.

Limitations and future research

There are some limitations to this research. First of all, the language issue. This research is conducted in the Netherlands by a Taiwanese researcher, with participants from different countries. There was a certain amount of information which needed to be translated, such as the introduction before the activity, the descriptions during the activity, interview questions, and whole conversations were also translated. The accuracy of the translation was not always on point, and possibly not clear in cases which possibly, as a result, caused some misunderstanding from both participants and researcher side. Since the content of conversations is the key component in this research, in order to reduce the possible misunderstanding as much as possible, it is recommended for future studies that similar research is to be executed in mother tongue with native Dutch researchers and native Dutch visitors.

Second, this research was conducted on a small-scale, because it was an exploratory study. The results did not have statistical meaning because of the small number of the samples. Bigger-scale research is necessary to be executed to clarify the unknown factors from this research. Therefore, since this narrative reflection activity does not need active assistance during the activity, developing a digital narrative reflection activity which is based on the current activity is recommended to future studies. In the current study, this kind of narrative reflection showed some possibilities to facilitate science learning. It needs bigger scale research to investigate its real effects. Developing a digital version of narrative reflection activity can enroll more families by preparing more digital devices (i.e. laptops). Moreover, digital activity can be extended more easily and be more flexible than the current activity. It can easily be added extra information if necessary. Additionally, because the current activity of narrative reflection is also a hands-on and interactive activity, NEMO Science Museum can directly use it as a new exhibit if the positive effects have been proved by future research. Thus, developing a digital activity of narrative reflection based on the current activity is recommended.

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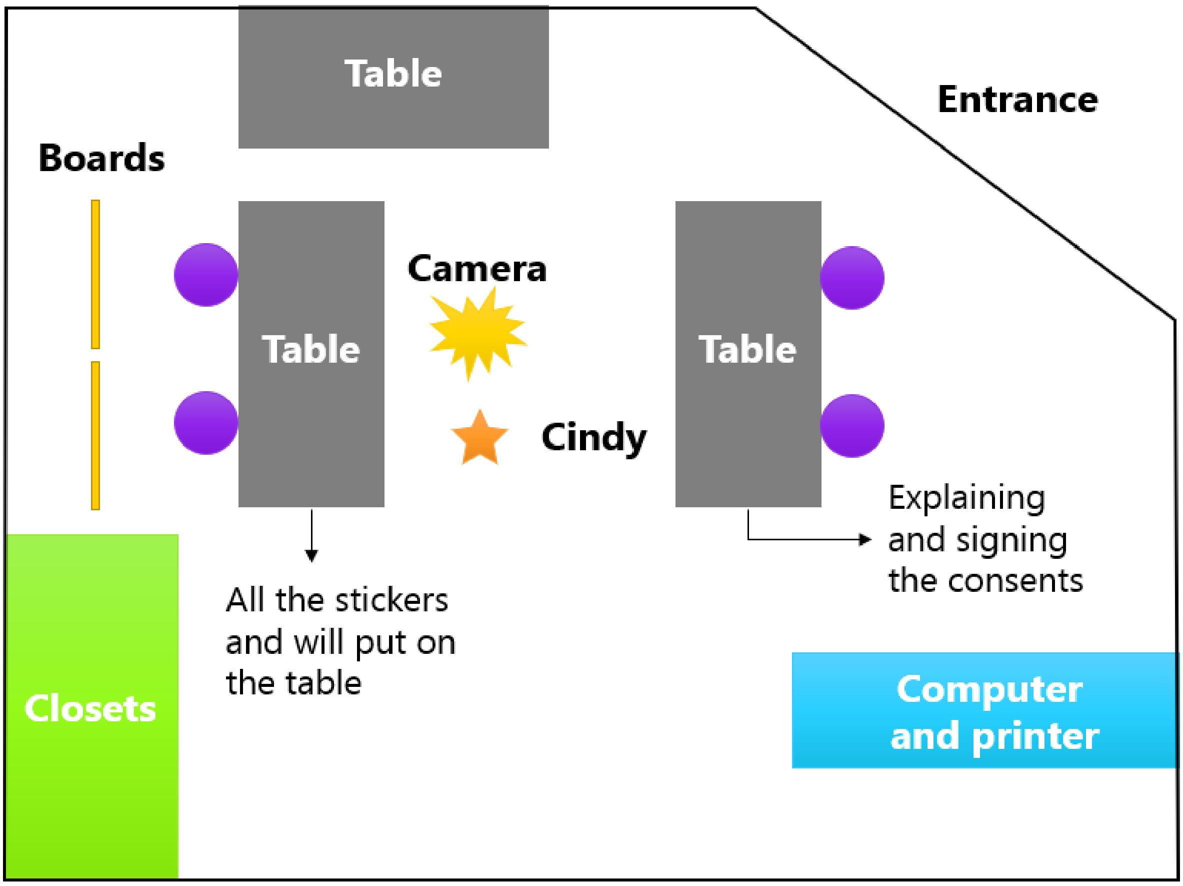
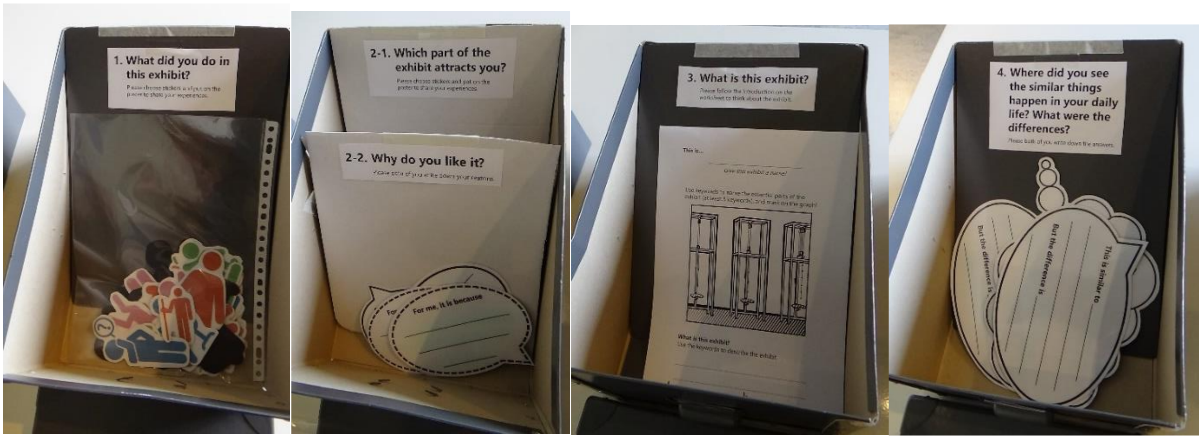
Appendix 1: Experiment setting

The set plan of in R&D room



The setting photos



Appendix 2: Interview questions (with translation)

Questions for child

- What do you think about the activity you have just done?
  - Did you enjoy doing it?
  - What did you like most?
  - Can you try to explain why?
- 對於剛剛的活動你有什麼想法?
  - 你覺得很好玩嗎?
  - 哪個部分你最喜歡?
  - 可以解釋一下為什麼嗎?

- Did you discover something new while doing the activity??
  - What did you discover? Can you describe that for me?
    - Did you learn something new about the phenomenon?
    - Did you learn something new about your father or mother?
  - How did you discover? Can you explain the process to me?
- 在這個活動中你有什麼新發現嗎?
  - 你發現了什麼? 可以解釋一下嗎?
    - 在這個活動中你有學習到新的科學現象嗎?
    - 在這個活動中你有從爸爸媽媽身上學到什麼東西嗎?
  - 你是怎麼發現的? 可以回想並解釋一下怎麼發現的嗎?

- In your opinion, how does science relate to your life?

- Can you explain in what way?
- Does this activity give any influence on your attitude?

♦ 你覺得，科學跟你的生活有什麼相關?

- 你可以解釋一下為什麼嗎?
- 你的想法是否在經過這個活動後有什麼影響?

♦ The approach of this activity was: making a poster, discussing your experiences with your mother/father, and linking those experiences to your personal life. Would you like to use this approach again when visiting NEMO or another museum in the future?

- Can you explain to me why?
- If yes, how are you going to do it?

♦ 這個活動主要是一起做一張海報，和爸爸媽媽討論你們的經驗，然後江浙接經驗和的你的生活做結合。像這樣的手法，下次你去參觀博物館的時候你回想也用用看嗎?

- 為什麼?
- 如果你會想要用，你可以說說你會怎麼用嗎?

Questions for adult

- What do you think about the activity you just did. In which you and your child could reflect on your experiences in NEMO?
  - Did you enjoy doing it?
  - How do you value it?
  - Can you explain your reason?
- 對於剛剛的活動你有什麼想法?
  - 你覺得很好玩嗎?
  - 你怎麼看待、評價這樣的活動?
  - 可以解釋一下為什麼嗎?

- Did you learn something new from this activity?
  - What did you discover? Can you describe that for me?
    - Did you learn something new about the phenomenon?
    - Did you learn something new about your children?
  - How did you discover? Can you explain the process to me?
- 在這個活動中你有什麼新發現嗎?
  - 你發現了什麼? 可以解釋一下嗎?
    - 在這個活動中你有學習到新的科學現象嗎?
    - 在這個活動中你有從小孩身上學到什麼東西嗎?
  - 你是怎麼發現的? 可以回想並解釋一下怎麼發現的嗎?

- What do you think your child/children have learned from this activity?
  - How did you notice that?

- How did he/she/they learn that?

♦ 你覺得小朋友在這個活動中學到了什麼?

- 你是怎麼注意到這一點的?
- 你覺得他怎麼學到這個的?

♦ In your opinion, does science relate to your life?

- Can you explain in what way?
- Does this activity give any influence on your attitude?

♦ 你覺得，科學跟你的生活有什麼相關?

- 你可以解釋一下為什麼嗎?
- 你的想法是否在經過這個活動後有什麼影響?

♦ The approach of this activity was: making a poster, discussing your experiences with your mother/father, and linking those experiences to your personal life. Would you like to use this approach again when visiting NEMO or another museum in the future?

- Can you explain to me why?
- If yes, how are you going to do it?

♦ 這個活動主要是一起做一張海報，和爸爸媽媽討論你們的經驗，然後江浙接經驗和的你的生活做結合。像這樣的手法，下次你去參觀博物館的時候你回想也用用看嗎?

- 為什麼?
- 如果你會想要用，你可以說說你會怎麼用嗎?