

## Science Museum Exhibits' Summative Evaluation with Knowledge Hierarchy Method

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(Received: 09.04.2016, Accepted: 26.07.2016)

**DOI:** 10.20308/ejpe.60470

### ABSTRACT

It is aimed in this research to measure via knowledge hierarchy the things regarding exhibit themes learned by the visitors of the exhibits and compare them with the purpose that the exhibits are designed for, thereby realizing a summative evaluation of the exhibits by knowledge hierarchy method. The research has been conducted in a children's science museum with totally 12 middle school students, nine of which are in the sixth grade and three of which are in the seventh grade. Semi-structured interview forms have been used to make interviews with those students before and after the visit, and based on these interviews their knowledge levels have been identified. It has been found out that the students at the lower levels of the knowledge hierarchies of the exhibits have moved up to the higher levels after the visit. An accumulation of the students has been observed at higher levels and the exhibits meet the purpose of the visit.

**Keywords:** Free-choice learning, science museum, knowledge hierarchy, exhibit evaluation.

### INTRODUCTION

In our globalizing world the countries steering technology and economics are the ones which build their education system in line with this positioning. One of the steps taken by our country to be a part of this competition has been designing the curriculum of science and technology course as to raise individuals keen on investigating, thinking critically and learning throughout their lives (TTKB, 2005, p.5). Even if the schools are the primary institutions where formal science education is realized, science education does not come through a single way and same purpose. Since the resources of learners, the process or reason of learning may change (Wellington, 1990; Dierking ve Falk, 2003), out-door learning is frequently preferred in science education.

It is generally stated that the learning at school is formal learning while the learning at environments such as museums is informal learning (Anderson, Lucas ve Ginns, 2003). On the other hand, non-formal learning is the type of learning which is realized in the institutions with a curriculum and plan and where there is need for a guide to transmit the knowledge as it is in

formal learning (Eshach, 2007). Learning that is rather depending on the internal motivation of the learner and can be realized in the light of the interests and needs and can be a life-long process via means such as reading books, making discussions, strolling around in a park or visiting museums, at the place and time determined by the learner is called free-choice learning (Dierking ve Falk, 2003; Falk, Storksdieck ve Dierking, 2007). Learning settings such as museums are frequently made use of by the individuals desiring to have different experiences, satisfy their curiosity and manage their own learning (Griffin, 1998).

International Council of Museums (ICOM, 2007) defines museums as non-profit and permanent institutions serving to the society, contributing to the students' for having a good time and doing research. Science centers and museums have offered the learners the opportunity to manage their own learning and draw conclusions and these organizations have drawn away from the approach of 'transmitting teacher /passive learner' by adopting a learning process whereby the learners play an active role in understanding and creating the knowledge (Johnson, 2013).

In the research conducted on science museums, evidence has been encountered about the facts that the knowledge of the students visiting science museums can be increased, they can acquire new competencies and their career choices can be affected, they can form concepts or restructure existing concepts, they can experience a rise in their interest towards science and in their academic success, they can become science-literate or start to associate scientific subjects with their daily experiences (Henriksen ve Jorde, 2001; Fadigan ve Hammrich, 2004; Anderson, Lucas, Ginns ve Dierking, 2000; Ertaş, Şen ve Parmaksızoğlu, 2011).

Evaluation of science museum exhibits involves comparison of the knowledge expected by the designers of the exhibit to be learned by the visitors and the knowledge that is learnt by the visitors. Screven (1990) defines three stages for exhibit evaluation which are pre-evaluation, formative evaluation and summative evaluation. Front-end and formative evaluation take place in the stage of planning and installation while summative evaluation takes place when the exhibit is completed and put into service of the visitors (Dean, 2002).

As measurement methods used in formal learning are realized within a short period of time, they are not suitable for the measurement of learning which is realized through a long period of time in informal settings and may change depending on the interaction at museum (Beetlestone, Johnson, Quin ve White, 1998). Therefore, Perry explained learning of museum visitors with the Selinda Model he has developed and assessed learning from the perspectives of outcome, engagement and motivation. Outcome perspective focuses on what the visitor acquires from his experiences in the museum, engagement perspective focuses on the relationship with the physical, emotional, intellectual and social interaction process of the visitor, while motivation perspective focuses on the psychological needs affecting learning in informal settings and the desire to learn.

Understanding is a part of outcome perspective of Selinda Model. It deals with the quality and quantity of the contribution of the exhibits to the learning process of the visitor rather than their teaching aspect. Perry (2012) suggested using the method of knowledge hierarchy for the measurement of understanding outcomes of the visitors with differing reasons of visit, understanding processes and profiles. According to knowledge hierarchy, every exhibit has its own structure of knowledge that can be transferred to the visitor and measured (Bitgood, 2013). This structure is the intersection of the understandings of the designer and learner about the subject of the exhibit. The array of the knowledge hierarchy consists of what the visitor knows

in the context of the exhibit instead of what he knows about the subject. It measures which main subjects of the exhibit the visitor has learnt at the end of the visit and how far he has progressed in the knowledge hierarchy. One of the important components of determining the success of the exhibit is measuring learning (Perry, 1993).

Knowledge hierarchies usually consist of five or six levels, starting at level 0 and ending at level 5. Even though the knowledge hierarchies obtained may differ across different research, they usually have the same structure. This structure is as follows;

Level 0: I don't know or I'm not interested

Level 1: I don't know but I'm interested in this subject and would like to know more about this

Level 2: I think I know but my knowledge in this subject is limited and insufficient

Level 3: There are things I'm sure about in this subject but at an elementary level.

Level 4: I have deep and progressive knowledge about the concepts covered in the exhibit (Perry, 2012)

It is difficult but not impossible to design exhibits which both support learning and draw interest (Allen, 2004) in an environment where the visitors may also prefer to remain indifferent (Vance & Schroeder, 1992) to the exhibit while they have the options of stopping by, looking and listening. While measuring learning is an important criterion in discovering the success of the exhibit (Perry, 1993), the complex structure of the interaction between the visitor and the exhibit can only be understood if it is viewed from the perspective of the visitor (Allen & Gutwill, 2004).

A summative evaluation was made in the Field Museum in Chicago by measuring the knowledge of the participants with a 6-level knowledge hierarchy for the Underground Adventure exhibit. It was found out that knowledge of many of the visitors were at levels 1 and 2, nobody was at level 0, some of the participants advanced to level 3, and levels of the participants who had been at levels 4 and 5 from beginning through the end of visit. It was deduced that the exhibit was not suitable for the families with children at young ages since children at the age of 5 or below were afraid of the darkness, and it was very entertaining for the families with children at older age groups (Schaefer, Perry, & Gyllenhaal, 2002).

Summative evaluation of the Magnetic Maze exhibit built in the Discover-Land science center in Australia was made by measuring the knowledge of child visitors with 4 level knowledge hierarchy. The exhibit was designed for letting the children discover how the magnets behave. Even though it was determined that many of the children interacting with the exhibit were at level 4 at the end of the research, it was found out during observations that the string pinning the stick to the table was short and the stick was dangling below the table and it was not noticed by the children. When the string was lengthened, the stick seemed like a hammer with the magnet at its tip and the children damaged the exhibit thinking that the stick would be used as a hammer. Then the magnets were removed from the tip of the stick and put at the side of the stick, therefore it didn't look like a hammer any longer and it was ensured that the exhibit be used appropriately for its designing purpose (Rennie & McClafferty, 2002).

No research has been encountered in which exhibits are assessed, learning is measured with knowledge hierarchy or summative evaluation is realized in the literature review performed on the science museum research done countrywide.

## **METHOD**

Qualitative research method has been used in this study in which the things students learn in a museum exhibit. Yin (2009) says that if it is aimed to understand in depth a phenomenon limited with context, the method of case study must be used. In this research case study has been used

for examining the interaction between the student and the museum exhibit. Museum exhibit is a “case” in this research.

### **Participants**

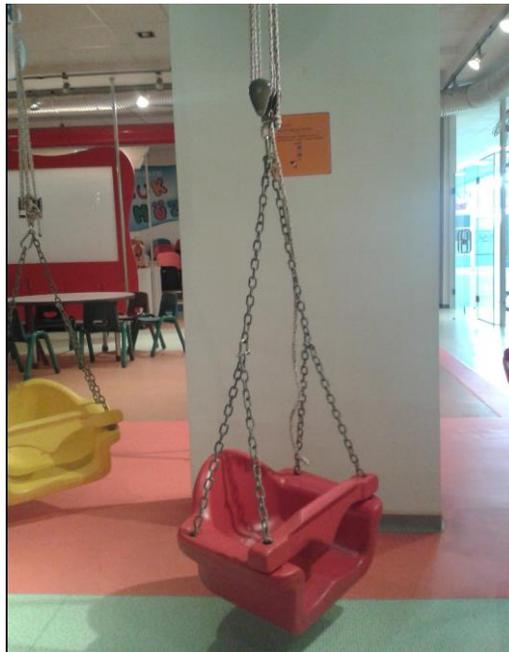
The study was carried out in 2013-2014 academic year and a total of 12 students participated in the study, 9 of which were 6th grade and 3 of which were 7th grade students of a private secondary school in Istanbul. The students were selected according to convenient sampling and since the science museum chosen for the research is located in the school where the researcher works as a teacher and the researcher is the person responsible for the science museum. Convenient sampling is a sampling method preferred in the cases where the researcher has restrictions for time, cost, location and research area. Because the credibility and diversity of data to be collected from the sampling selected solely based upon this method is less than that in the other research employing other sampling methods (Merriam, 2009), purposeful sampling has been realized based on the experiences of the researcher about research area and conditions ( Denscombe, 2010).

### **Implementation**

Implementation phase involves a period of two weeks and consists of 6 phases.

#### *Phase 1*

In the implementation phase of the research, first the exhibits planned to be subjected to the evaluation was determined. Since it was considered to choose an easily accessible sampling in determining the exhibits, the ones which were suitable for the levels of 6th and 7th grade students were selected. They were “Pulleys”, “Wind Power Simulation” and “Triangle Mirror” exhibit.



***Figure 1. Pulleys Exhibit***



*Figure 2. Wind Power Simulation*



*Figure 3. Triangle Mirror*

*Phase 2*

Temporary knowledge hierarchies for the exhibits were formed based upon the previous observations and experiences of the researcher in the science museum.

*Phase 3*

Interviews with the students were realized in this stage. Knowledge hierarchies of the exhibits were updated considering the comments of the students about the knowledge about the selected

exhibits and the updated levels of the students in the knowledge hierarchies were detected. This process took one week.

#### *Phase 4*

This phase involved the visit to the science museum. It was realized during the class allocated for science club activities and the students participating in the interviews were invited to the science museum during that class. The visit to the science museum took approximately 40 minutes. The students were asked to experience the exhibits in the museum independently during that time.

#### *Phase 5*

This phase involved the interview after the visit and these interviews were realized on the day following the visit. The comments of the students in the first interviews were considered and questions were asked. They were asked to express their comments on the exhibits.

#### *Phase 6*

The levels of the students in knowledge hierarchies were determined again and the exhibits were evaluated in terms of the levels of understanding.

### **Researcher's Role**

The role of the researcher is acting as the participant for observing the interactions, during the visit to the science museum, of the students with the science museum exhibits that were selected. In this stage the researcher helped physically the students use the exhibits, which they had difficulty in, and gave no answer to the questions of the students about the knowledge involved by the exhibits.

### **Data Collection**

In the third and fifth phase of the implementation, the interviews made with the students were recorded on voice recording devices and then they were transcribed. Semi-structured interview forms were used for the interviews made with the students and every interview took approximately 10 minutes. 2 separate interview forms were filled before and after the museum visit for an exhibit. Students drew the situations and forms they wanted to describe on the papers during the interviews. By this means, the researcher aimed at becoming sure that the questions he asked were understood by the students and the answers given orally by the students were understood by the researcher himself accurately. The contacts of the students with the exhibits during the science museum visit were recorded by the researcher using unstructured observation form.

### **Data Analysis**

Since the framework of the research is pre-defined, data were evaluated with descriptive analysis process. Yıldırım & Şimşek (2011) define four phases for descriptive analysis:

1. Forming a frame for the descriptive analysis: forming the framework where knowledge hierarchy data of the exhibit, built in the light of the data obtained from the researcher's experiences as the person in charge of the science museum and from the interviews made with the students before the museum visit.
2. Processing data according to thematic frame: In this phase, the interviews with the students before the visit which were converted into written documents were examined within the frame of knowledge hierarchy of the exhibit and the comments of the students

shedding a light onto which level of the knowledge hierarchy they are at were determined. The process applied on the interviews made before the visit were applied again on the interviews made after the visit.

3. Defining Findings: The student comments in the second phase supporting the levels of the students in the knowledge hierarchy were included in the findings in this phase as the quotes from the students who were in the different levels of the knowledge hierarchy.

4. Interpreting comments: the levels of the students before and after the science museum visit in the knowledge hierarchy of the exhibit were compared and it was aimed to explain the cause-effect relationship between the findings.

### Validity and Reliability

Knowledge hierarchies of the exhibits built up by the experiences of the researcher as the person in charge of the science museum have been verified by three science and technology teachers who work in the same school and closely know the science museum and exhibits in which the research has been carried out.

In the discussions made for determining the knowledge hierarchies of the students, the students were allowed to draw what they wanted to describe and what they visualize in their minds on a paper in order that these could be understood better by the researcher, besides recording the interviews with voice recording devices and using observation form during science museum visit, all of which led to a diversity of data.

Consistency between the answers given by the students during the interviews and the notes taken by the researcher during science museum visit contributed to the reliability of the research.

### FINDINGS

This part includes the comments about the students in the various levels of the knowledge hierarchies of the exhibits before and after the science museum visit and the comments about the students' levels.

*Table 1. Number of students in knowledge hierarchy levels before and after the museum visit*

	Pulleys		Wind Power Simulation		Triangle Mirror	
	Before visit	After Visit	Before visit	After Visit	Before visit	After Visit
Level 0	3	-	-	-	-	-
Level 1	-	1	-	-	-	-
Level 2	4	3	6	-	2	1
Level 3	2	1	5	1	1	-
Level 4	3	7	1	11	9	11

Table 1 shows that number of students who were at lower and middle level of the knowledge hierarchies was higher than the number of those who were at higher levels of the hierarchy for the Pulleys Exhibit before the museum visit. It is observed, however, after the museum visit there are more students in the higher level of the knowledge hierarchies in

comparison to the other levels for all exhibits. Below is the distribution of the students in detail according to their levels.

### **Pulleys Exhibit**

#### ***Level 0: I don't know what a pulley is.***

This level of knowledge hierarchy represents the students who don't know what a pulley is, which is a type of simple machine. There were three students in Level 0 and they didn't know anything about the pulley. There were no students at this level of knowledge hierarchy after visiting the science museum.

#### ***Level 1: There is the load that is intended to be lifted on one tip of the rope and a force pulling the rope on the other tip.***

Level 1 in the knowledge hierarchy represents the students who explain simply the pulley and its operating principle. No students were found who were at this stage of the knowledge hierarchy before or after the science museum visit.

#### ***Level 2: There are cases where pulleys are used in daily lives.***

This level of knowledge hierarchy represents the students who are able to give examples for the daily usage of the pulleys besides explaining the principles of operating of a pulley. Four students were determined to be at this level. Although the students at level 2 were able to give examples for the usage of the pulleys they were unable to link the load with the force and simply said that the pulleys provided convenience. Three students who were at level 2 were found after the science museum visit and it was found out that two of these students were also at level 2 before the science museum visit whereas one student advanced from level 0 to level 2.

#### ***Level 3: A piece of load can be lifted up with a force that is equal to the weight of the load at minimum, using a pulley.***

This level of knowledge hierarchy represents the student who can address and explain accurately the force needed for lifting a load with a fixed pulley. Two students were determined to be at this level. After the science museum visit, one student was determined to be at this level of the knowledge hierarchy.

#### ***Level 4: Heavier loads can be lifted with less force using movable pulleys.***

This level of knowledge hierarchy represents the students who state that a load can be lifted with a force less than its weight, using moveable pulleys. 3 students were detected to be at this level of knowledge hierarchy, all of whom were 7th grade students. After the science museum visit, 7 students were detected to be at this level. 3 of these students were at level 4 before the visit, too and one student advanced from level 0, one student from level 2, two students advanced from level 3 to level 4.

### **Wind Power Simulation Exhibit**

#### ***Level 0: I don't know what wind power is.***

This level of knowledge hierarchy represents the students who cannot specify that the wind had a power due to its movement. No student has been found to be in this level. Previous experience of the researcher as a museum staff implies that even preschool students at the ages of 5 and 6 could deduce that wind, although it is not visible, might cause light objects to move or drop. No student has been found to be in this level after the visit to the science museum.

***Level 1: Objects like propeller can rotate with wind power.***

This level of knowledge hierarchy represents the students who specify that the wind had a power and objects such as wind rose, wind mill or propeller can be rotated by this power of the wind. No student has been found in this level neither before nor after the visit to the science museum.

***Level 2: Wind power turns into electric power with wind mills.***

Students in this level of the knowledge hierarchy express that the power the wind has is converted into electrical energy thanks to windmills. Six students have been found to be in this level and only one of these students could specify that windmills are used for converting wind power into electrical power. Remaining five students have used different concepts instead of wind mill. No students have found to be in this level after the visit to the science museum.

***Level 3: Number of wings of the windmills affects the quantity of the electricity generated.***

Students in this level of the knowledge hierarchy specify that there was a relationship between the number of the wings of the windmills and the quantity of the electricity generated and make comments to explain this relationship. Five students were found to be in this level before the visit to the science museum while no students have been found to be in this level after the visit.

***Level 4: There is an ideal number of wings for making the most of wind mills.***

Students in this level of the knowledge hierarchy specify that wind mills had three wings in order to generate electrical energy in the most efficient way besides establishing a relationship between the number of wings of the windmills and the power generated. While only one student was found to be in this level of the knowledge hierarchy before the visit to the science museum, 11 students have found to be in this level after the visit. Six students from Level 2 and 4 students from Level 3 have advanced to Level 4.

### **Triangle Mirror Exhibit**

***Level 0: I don't know how the image is formed on the plane mirror.***

This level of the knowledge hierarchy represents the students who cannot explain how their image is formed on a plane mirror. No students have found to be in this level neither before nor after the visit to the science museum.

***Level 1: My image is formed on a plane mirror with reflection.***

This level of knowledge hierarchy represents the students who explain that their image on the plane mirror is formed with reflection. No students have found to be in this level neither before nor after the visit to the science museum.

***Level 2: Two or more mirrors are used for more images.***

This level of the knowledge hierarchy represents the students who specify that they could obtain more images by using two or more mirrors thanks to reflection but cannot explain the reflection between the mirrors fully. Two students were found to be in this level before the visit to the science museum while one student has been found to be in this level after the visit.

***Level 3: My images on a triangle mirror are formed through the mirrors' reflection of the rays, originating from me and reaching the mirrors, between each other.***

This level of the knowledge hierarchy represents the students who specify that more images are created with more number of mirrors and accurately explain the reflection of the image by the mirrors. While only one student was found to be in this level before the visit to the science museum, no student was found to be in this level after the visit.

***Level 4: The number of my image is infinite since the mirrors reflect my image to each other in a triangle mirror.***

This level of the knowledge hierarchy represents the students who specify that the mirrors reflect the images to each other endlessly and therefore infinite number of images are created.

The students in this level can visualize the reflection as a cycle in their minds and can associate this reflection with the number of images. 9 students were found to be in this level of the knowledge hierarchy before the visit to the science museum and all of the 7th grade students were in this level. 9 students have found to be in this level of the knowledge hierarchy after the visit. While seven of these students were also in Level 4 before the visit to the science museum, one of them has advanced to Level 4 from Level 2 and the other has advanced here from Level 3.

## **DISCUSSION AND CONCLUSION**

No student at level 1 was found in the knowledge hierarchy of pulleys exhibit before the science museum visit and it was observed that the students were distributed among other levels evenly. That there was no student at Level 1 conflicts with Perry's (2012) argument that there may be students at all levels of the knowledge hierarchy. The reason may be that questions needed for exactly discovering the knowledge of the students at level 1 were asked. Another finding about pulleys exhibit was that all the students at Level 4 were 7th grade. Pulleys as a subject is included in the 1st term curriculum for Science and Technology. The research was done in the 2nd term. Therefore it is an expected result that the 7th grade students having learned the subject of Pulleys were at level 4.

That the majority of the students were at level 4 of the knowledge hierarchy of the pulleys exhibition after the science museum visit and realization of learning after a practice or interaction is an expected result. Additionally, this judgement supports previous studies carried out on the science museums (Henriksen ve Jorde, 2001; Fadigan and Hammrich, 2004; Anderson, Lucas, Ginns and Dierking, 2000; Spiegel et al., 2012; Ertaş, Şen and Parmaksızoğlu, 2011). Inability of some of the students to advance to the higher levels of the knowledge hierarchy might arise from the difficulties they had while experiencing the exhibit and their failure to understand how to use the exhibit.

In the knowledge hierarchy of the Wind Simulation, most of the students were in level 2 and Level 3 before the visit. Since the knowledge hierarchy covers a wide range of knowledge, Level 0 and Level 1 might have remained below the knowledge levels of the students.

In the knowledge hierarchy of the Triangle Mirror, most of the students are in Level 4 before the visit. Level 4 consists of the students who can explain reflection and can make deductions about the number of images formed as a result of the reflection. Mirrors and Reflection is a topic of 6th grade science and technology subject. The students had studied Mirrors and Reflection topic one month before the time the research was conducted. Therefore, it is an expected situation that the students can make deductions about reflection and formation of image. Another factor is may be that many images are formed on the mirrors positioned against each other, which is one of the situations they encounter in their everyday lives. Students have often made this analogy during the interviews.

It has been concluded after the visit to the science museum that most of the students were in the Level 4 of the knowledge hierarchy of the Pulleys Exhibit, they mostly accumulated in Level 4 in the Wind Simulation Exhibit and the number of students who accumulated in Level 4 increased in the Triangle Mirror exhibit. Learning is the expected result of this practice or interaction. On the other hand, this conclusion supports the previous research made on science museums (Henriksen and Jorde, 2001; Fadigan ve Hammrich, 2004; Anderson, Lucas, Ginns

ve Dierking, 2000; Spiegel et al., 2012; Ertaş, Şen and Parmaksızoğlu, 2011). The reason for some of the students not to advance to the higher levels in the knowledge hierarchy may be arising from the difficulties they had while experiencing the exhibit and the fact that they could not understand how the exhibit was used.

In comparison of the designing purpose of the exhibits and the things the students have learnt, evidence has been found for the facts that the designing purpose and the things students have learnt match up with each other and students have met the designing purpose of the exhibits even if all of them could advance to the highest levels of the knowledge hierarchy after the visit to the science museum.

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