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# Transformation of Science Museums into Science Centers as a Reflection of Active Learning in Museum Education on Architecture*

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## ABSTRACT

In addition to preserving the important works they contain, museums have the function of informing their visitors about their collections through exhibitions. With these features, the differences in the conservation-focused or education-oriented approaches of the museums, which are cultural education environments, draw attention. In museums where the protection of objects is at the forefront, visitors are positioned as a passive observer as the works are kept as far away from the visitor as possible. The question of the research is how museums, which are the other group, prioritizing the educational mission, are affected by the studies on learning methods. For this reason, active learning, constructivist and experiential learning methods, which are a current approach, have been researched and the relationship between the museum setup and the visitor has been examined. Then, science museums and science centers with a dominant educational mission were selected to be examined with this perspective. Selected examples were examined in terms of exhibition methods and architectural setups. In these museums, it has been observed that multi-sensory experience is given importance while providing the opportunity for active participation to the visitor. It has been understood that there is a strong bond between the visitor and the museum, both through these experiences and the new programs and functions added to the museums. In the architectural setups of such museums, the convenience of the exhibition to offer new experiences each time gains importance. The importance of hosting the potentials of spatial changeability and using architectural technologies that support the experience has been understood.

Keywords: Science museum, education in museum, active learning, experience

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# Müze Eğitimciliğinde Aktif Öğrenmenin Mimarlığa Yansıması Olarak Bilim Müzelerinin Bilim Merkezlerine Dönüşümü*

**Hilal KAYA DİLMEN**

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## ÖZ

Müzeler topladıkları önemli eserleri korumanın yanı sıra, sergiler aracılığı ile koleksiyonları hakkında ziyaretçilerine bilgi verme işlevleri taşımaktadır. Bu özellikleri ile kültürel eğitim ortamları olan müzelerin, koruma odaklı ya da eğitim ağırlıklı yaklaşımlarındaki farklılıklar dikkat çekmektedir. Nesneleri korunmanın ön planda olduğu müzelerde, eserler ziyaretçiden olabildiğince uzak tutularak sergilendiğinden, ziyaretçiler pasif bir izleyen rolüne konumlanmaktadır. Diğer grup olan eğitici misyonu önceleyen müzelerin, öğrenme yöntemlerine dair yapılan çalışmalardan nasıl etkilendiği ise araştırmanın sorusu olmuştur. Bu nedenle, öncelikle, güncel bir yaklaşım olan aktif öğrenme, yapılandırmacı ve deneysel öğrenme yöntemleri araştırılmış, müze kurgusu ve ziyaretçi ile ilişkisi incelenmiştir. Ardından eğitim misyonu baskın olan bilim müze ve merkezleri bu bakış açısı ile irdelenmek üzere seçilmiştir. Seçilen örnekler, sergileme yöntemleri ve mimari kurguları açısından incelenmiştir. Bu müzelerde, ziyaretçiye aktif katılım imkânı sunulurken, çoklu duyusal deneyime önem verildiği gözlenmiştir. Hem bu deneyimler, hem de müzelere eklenen yeni program ve fonksiyonlar aracılığı ile ziyaretçi ve müze arasında güçlü bir bağ oluştuğu anlaşılmıştır. Bu tür müzelerin mimari kurgularında, serginin her seferinde yeni deneyimler sunmaya elverişliliği önem kazanmaktadır. Mekânsal olarak değişebilirlik potansiyelleri barındırmanın ve deneyimi destekleyen mimarlık teknolojilerini kullanmanın önemi anlaşılmıştır.

Anahtar Kelimeler: Bilim müzesi, müzede eğitim, aktif öğrenme, deneyim

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## EXTENDED ABSTRACT

In the classical museology approach, collecting, accumulating, and preserving valuable works are at the forefront. In museums designed within this framework, visitors are presented with a specific travel route, an inflexible and rules-based exhibition (Artun, 2006). Thus, museums have started to be structures that contribute to social and cultural development as well as exhibiting. It has taken an active role in transferring historical information from the past to new generations and raising awareness of society. In addition, it has become a cultural and educational centers by undertaking the task of gaining knowledge and experience.

An important part of the museums that undertake an educational mission are the science museums that emerged after the industrial revolution. These structures, which were first named as "natural history museum, industry museum", took their present form with modernization. Science museums are structures that offer education on science, technology and various subjects to visitors of all ages. This type of museum has started to convey information with applied and experimental activities in addition to classical exhibition methods.

Towards the end of the 20th century, "science centers" began to be opened with the use of experimental methods in science museums. Unlike the structure of museums that monitor exhibition objects remotely, science centers have taken on the role of teaching visitors by conducting experiments and practical activities. In addition, science centers include more public functions, unlike museum architectural programs. It has a setup that includes various programs such as workshops and conferences as well as exhibition areas.

It is possible to see science museums and centers, which have an important place in museum education, as a complement to formal school education. In other words, they are institutions that prove scientific concepts and rules by having them experience instead of showing them to the visitor, while entertaining the visitors and making them love science in this way. Bozdoğan (2007) lists the most important duties of science museums as arousing curiosity in visitors, helping students in their career choices, entertaining while learning, providing a scientific perspective and developing creative thinking skills (Karakaş, 2020). These approaches require the use of informal education methods in science museums and centers.

Learning methods, which are the subject of educational sciences, emerged with the belief that the mind is a black box, but it has been understood that it has a cognitive and affective dimension that makes sense from experiences (Aydınlı, 2015). Constructivist learning theory, pioneered by Piaget, suggested generating new ideas by exploring, discussing and generating hypotheses. Hein (2006) stated that this understanding has started to be implemented in museums in his article called "Education in a Museum". Experimental learning method, which aims for lifelong learning, is the process in which knowledge is formed through the transformation of experience (Kolb et al., 2001). In museums, this method is observed by establishing a relationship with the body while exploring objects. The use of the senses through the body also brings up the concept of multi-sensory experience. Pallasmaa (2019), who works on this subject, argues that the senses are effective in learning when they are used together, not separately. He claims that there are different senses in addition to the five known senses. With the use of these methods in museums, it is aimed that visitors gain different gains in a socio-cultural environment (Falk, 2016).

Within the scope of the article, it is thought that examining the educational methods used in science museums and centers and the exhibitions that ensure the active participation of the visitor will contribute to the understanding of the role of architecture in this, to see how learning can be facilitated.

For this purpose, the article:

- What active education methods, which are explained as constructivist, experimental and multi-sensory learning cover.
- How these methods were transferred to science museums and centers architecture and exhibition setup,
- How the interaction between the visitors and the exhibitions was established.

In order to answer these questions, first of all, conceptual research and literature review were made by making use of the articles, theses, books, journals and official websites of museums. During the research, first of all, the effect of active learning methods on the museum setup was investigated and then the new relationships he established with the visitors were examined. For the examination of the science museum and science center determined as the research area, three examples from different countries were selected, using similar learning methods. These are the Boston Museum of Science, the Experimentarium, and the Welios Science Center.

In the study, it was determined which learning method is used, which experiences are gained and which senses are addressed by the exhibitions of the selected museums that cover scientific fields such as physics, chemistry, biology, geography, archeology.

As a continuation of these findings, the examination of the exhibition areas has been added to the article in tables. In the exhibits of the Boston Science Museum, it is possible to observe the body being divided into small pieces by walking along a mirrored wall, to hear the sounds of habitat creatures, to feel the coldness of the poles by touching the ice walls, to experience the zero-gravity space travel by entering a full-size space cockpit. In Experimentarium exhibitions, it is possible to hear the sounds inside the human body in a virtual environment, to get into soap bubbles, and to experience sailing on a stormy day with the ship simulator. Finally, at the Welios Science Center exhibitions, it is possible to do mathematical mind exercises with puzzles, take a virtual tour to predict the weather, and try on the thick gloves of astronauts.

In addition, information was obtained about the spatial setup of the exhibition areas and the architectural program through the architectural plans. According to the common findings obtained from the architectural functions of the museums, in addition to the exhibition areas, conference and seminar halls that can be used by the visitors have been added to the architectural program. In the events held in these places, it is possible to interact between the experts in the field and the visitors. At the same time, celebrations and various concerts are held in these places for special occasions. Technological 4D cinemas and planetariums, developed with the influence of the digital age, offer virtual experience opportunities to exhibitions. Workshops are the areas of museums that create products and provide learning by generating. In these workshops, expert trainers assist visitors in obtaining a product or experimenting with the subject on display. Another function, cafeterias offer visitors the opportunity to rest, absorb what they have learned, and socialize. The museum shops, on the other hand, aim to leave a memory of themselves with the symbolic souvenirs offered at the end of the visit.

As a result, it aims to transfer information permanently by using constructivist and experimental learning methods in the examined science museums and exhibitions by touching, hearing, smelling, tasting, having fun, and trying. In particular, the increase in technological environments and the creation of experimental spaces that can accommodate the body have played an important role in this goal. In addition, architectural setups designed to be flexible, fluid, and adaptable to changes support these experiences. In this way, visitors who have meaningful experiences come to the museums again and again and gain new achievements each time.

## INTRODUCTION

The word museum was used to name the collection of Lorenzo, a member of the Medici family, in Florence in the 15th century, and to name ancient objects during the Renaissance in the 17th century. The museums represented the royal collections, collected and preserved important works until the 18th century (Artun, 2006). In the 18th century, the museum became an institution that exhibits works related to cultural heritage, as well as storing and preserving a collection. (Onur, 2012).

With the opening of the collections to the public in the 18th century, the foundations of museum plans were laid. The plan scheme designed by Jacques-Nicolas-Louis Durand is at the forefront of these studies and has been influential in the formation of many museums (Giebelhausen, 2006). Sculptural forms were preferred to reflect the works exhibited in the architectural structure of the museums built over time. There are ionic columned façades, triangular pedimented roofs, high-ceilinged exhibition spaces consisting of arched or vaulted corridors, and circular, domed and illuminated spaces called rotundas. The effects of these schemes continued to be seen in the museums built later.

Since museums began to be opened in many major cities of Europe in the 19th century, this period was called the "age of museums". The Altes Museum, built in Berlin in 1823-30 and designed by Karl Friedrich Schinkel, with a high floor, a colonnaded entrance and a large staircase, is an example of this period (Naredi-Rainer, 2004). Another example is the Natural History Museum (Figure 1), built in London in 1881. With the opening of natural history museums, it was possible to exhibit collections in such branches of science as botany, zoology and geology.

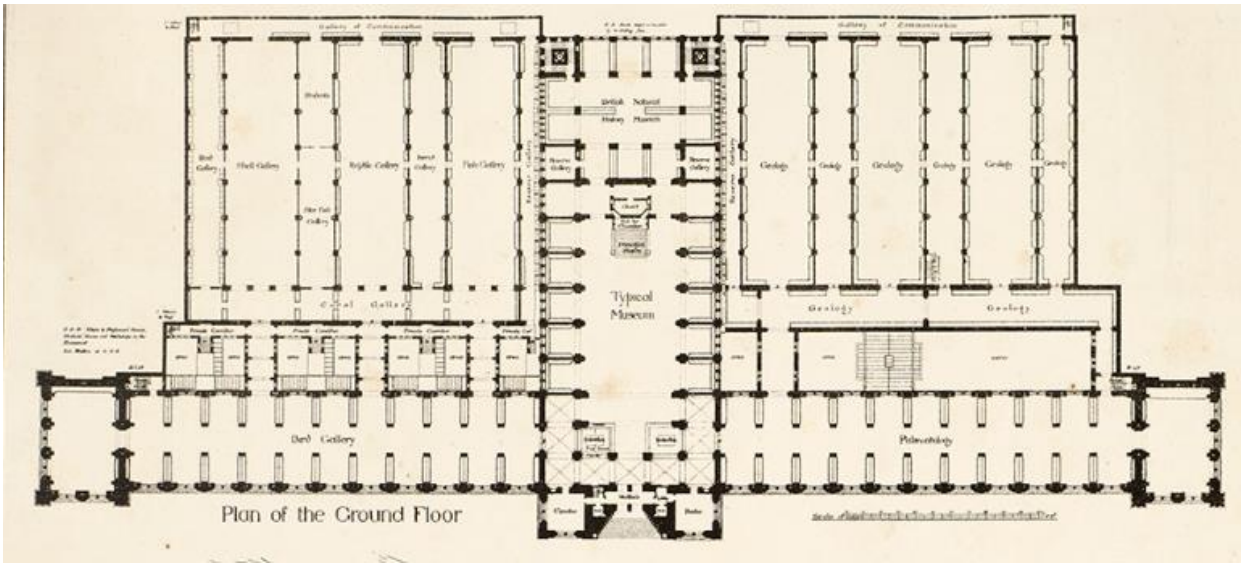


**Figure 1.** *Natural history museum london plan (URL-1)*

With the modernization steps in the world, museums have also started to change architecturally. The Crystal Palace structure, which has a prefabricated structure built in London in 1851, brought simplicity, and transparency to the exhibition areas (Atagök, 2002). Later in the 20th century, with the advent of the concept of "white cube", the ornate ceilings in the exhibition areas were replaced by white neutral areas.

While the most outstanding works and art of the history of civilization are exhibited in modernized museums, it is aimed that the visitor, as a museum audience, can develop a subjective aesthetic perception on subjects such as art and science. While the exhibited works are presented within a certain travel route and certain time limits, the audience is expected to act according to this planning of the museum. Museum architecture with this understanding offers the visitor the option to watch within the framework of the rules, with an inflexible and disciplined exhibition (Artun, 2006). In other words, the works are mostly shown to the visitors through exhibitions that appeal to the sense of sight. With this method, information is presented formally, one-way, from the museum to the visitor. The museum's teaching and presentation is didactic, and the bond with the visitor is very formal. In other words, the interaction of the visitor with the exhibition is weak and its role in the relationship is rather passive.

Today, information resources have greatly increased, accessibility of information has become easier and institutions supporting research have increased. Parallel to this situation, museums that collect important works and exhibit them safely have also been affected by this situation and have become a discipline with the functions of 'educating and interpreting' by undertaking the task of gaining knowledge and experience (Onur, 2012). In other words, museums have now turned into research, culture and education centers that preserve, research, communicate and exhibit the intangible and tangible human heritage, and serve the society and social development (Kandemir & Özlem, 2015).

The fact that museums take on a mission that educates while exhibiting rather than being merely conservation places makes us think that the relationship between the field of educational sciences and museum design should be considered together. Behavioral, cognitive, constructivist and experiential learning methods (Kırcı, 2013) put forward by theorists and scientists such as Watson, Thorndike, Skinner, Piaget, Dewey, Lewin, Kolb since the 1920's, and the concept of "multi-sensory experience", which argues that all senses have an active effect on learning, have been on the agenda in the field of educational sciences.

Science museums, which make experiments with the aim of popularizing science, amusing, arousing curiosity and excitement (Karakaş, 2020) are at the forefront of the museum types in which these methods are applied. Science museums and centers were chosen to be examined in terms of educational, spatial, sensory and experiential aspects within the scope of the study, due to their contribution to making museum education active and communicating with the exhibition. The subjects of the article are how constructivist and experimental education methods are presented to the visitors through exhibitions, which senses the exhibitions are prepared for, and what role is defined for the visitor in these structures.

## The Effect of Active Learning Methods on The Museum and The Visitor

It is known that until the 20th century, museums served their audiences through visual exhibitions. These exhibitions based on visual perception think that they have a sufficient learning style for the visitors who watch and observe. In this method, the participation of the visitor in the exhibition setup is not expected to be in a multifaceted interaction.

Over time, developments in educational sciences have shown that there are differences in people's learning styles, so the question of how museum visitors can have different learning styles and how to address learners with different styles in the exhibition has emerged. This topic examines the connection between both the museum setup and the visitor's experience in the museum with learning methods.

### *The Effect of Use of Active Learning Methods on Museum Setup*

Throughout history, many theoretical studies have been carried out to understand how human learning ability occurs. The idea of transferring information directly, which sees the mind as a black box, has become insufficient with the change of the age. Likewise, the effort to explain learning only in terms of stimulus-

response behaviors was not helpful either. It has been argued that learning over time can be a mental process with cognitive and affective dimensions. With new approaches, it has been discovered that the individual is an active learner who starts from mental models and new experiences, creates meaning and interprets (Aydınlı, 2015). These perspectives have revealed constructivist and experiential learning methods.

Thanks to the exhibitions and programs designed to use active learning methods in museums, it is aimed for the visitor to learn easily. At the same time, it was important for the visitors to reveal their self-learning nature and characters. Thus, visitors followed two types of paths, learning about global ideas (for example, learning that there are an incredible number of different species of plants and animals in the world) and special situations learned with distinctive learning styles (for example, learning how fast you spin by moving your arms and legs in and out on a gyroscope seat) (Falk & Storksdieck, 2005).

### *Constructivist Learning Method*

One of the leading founders of the constructivist learning method is Jean Piaget. According to Piaget, exploratory learning is important for children and adults in the construction of knowledge. The foundations of constructivist learning were laid with the Gestalt approach and then developed with Piaget's studies, and today it continues with deconstruction approaches (Aydınlı, 2015). Constructivism, which is an active learning method, is not limited to reading and listening, but aims to discuss, produce hypotheses, and develop new perspectives by exploring (Özdemir, 2017).

Hein (2006) in his article titled Education in the Museum stated that constructivist learning methods have started to be applied after the behaviorist-oriented research has lagged behind. With this understanding, the concept of education has changed from being a "defined content result" to "meaningful experience". Dewey, on the other hand, developed his ideas and educational theory on progressive museum education supporting this view (Hein, 2006). With the application of constructivist theory in museums, a dynamic way has been followed instead of transferring information directly. The exhibitions have developed the purpose of expanding ideas by establishing new bonds and meanings without focusing on the ideas that the visitor wants to learn. Constructivist exhibitions offered visitors the opportunity to validate, expand and encourage their own interpretations. At the same time, these exhibitions are designed by focusing on meaning and experiences (Onur, 2012). In museums designed with a constructivist approach, the focus is on the learner rather than the exhibition or subject content. Visitors' own perspectives and experiences are influential in the learning process (Gibbs et al., 2007).

### *Experimental Learning Method*

The theory aiming at life-long learning is the experiential learning method. The feature that distinguishes the experimental learning method from other methods is the experience factor emphasized in the learning process. For this reason, it is separated from cognitive theory, which emphasizes cognition over affect, and behavioral theory, which rejects experience in the learning process. Kolb defined learning as 'the process by which knowledge is created through the transformation of experience' and named this process the 'Four-Stage Cycle'. This method has been used to gain new experiences by transforming concrete experiences into concepts. The four stages consist of concrete experience, reflective observation, abstract conceptualization, and active experience (Kolb et al., 2001). According to John Dewey, the continuity of actions has influenced the development of experience. Thanks to the habits formed with the principle of continuity of experience, each experience has made a difference in individuals by taking something from previous experiences and changing the quality of future experiences (Dewey, 2007).

Experiences during the visit are as important as the information gained as a result of visiting museums (Gibbs et al., 2007). Hooper-Greenhill supports this view by stating that the tangible qualities that result

from the experiences are effective in the understanding and learning process throughout the museum visit. Experimental learning in the museum is provided by discovering objects and establishing a physical relationship. For example, the senses and body are used as sources of learning when touching objects, climbing stairs or exploring houses. (Onur, 2012). Thanks to the use of the body and senses as a means of experience, it is possible to create meaning from objects and develop imagination. Thus, the concept of multi-sensory experience emerged.

### *Multi-Sensory Experience*

Visual perception strengthens the formation of experience to the extent that it contains tactile features. Tadao Ando's linking of experience to the formation of tactile awareness rather than the effect of visual power (Frampton, 2002) supports this idea. According to Pallasmaa, experience, which is independent of the sense of touch, is disconnected from space and body. Unlike mere sight, visual perception, which gives information about hardness, surface texture, weight and temperature, has an important place in experience. Apart from the five main senses, there is a strong bond between space, matter and scale, thanks to many sensory experiences interacting with each other (Pallasmaa, 2019).

Although the senses are classified as seeing, hearing, smelling, touching and tasting, Ponty stated that these senses gain an affective meaning when they are evaluated together, not separately (Ponty, 2005). Thus, researchers and intellectuals have made different classifications about the multiple states of the senses. For example, the senses that Gibson (1950) called the five sense systems are the visual system, the auditory system, the taste-smell system, the basic wayfinding system and the tactile system (Onur & Zorlu, 2017). Likewise, Juhani Pallasmaa assumes that there are at least twelve sensory systems. These are 'touch, movement, balance, smell, taste, sight, temperature, hearing, language, living, conceptual sense and ego sense' (Pallasmaa, 2019).

According to Bachelard (1994), architecture is the art of creating meaning in addition to visual objects. Thus, meaningful architecture supports the formation of physical and spiritual experiences and strengthens the sense of self (Soltani & Kirci, 2019). Similarly, Pallasmaa states that this experience establishes a strong connection with one's sense of being in the world (Pallasmaa, 2012). In addition to these views, Vygotsky (1978) also argues that multi-sensory interaction is effective in increasing the sense of identity and self-awareness (Chatterjee & Hannan, 2016).

In the article, the types of exhibitions of the selected science museums and the senses of the visitors to try these exhibitions were examined. In this study, in addition to the senses of seeing, hearing, tasting, smelling and touching, the sense of "movement" as stated by Pallassmaa was also taken into consideration. The effect of shaping the exhibitions in the context of multi-sensory experience on learning was examined.

## *The Effect of The Use of Active Learning Methods on The Visitor*

The purpose of museum education can be explained as “the process of learning from collections by providing interpretations, explanations and programs, or by enabling the audience to make sense of their lives by creating memories, feelings and thoughts” (Woollard & Moffat, 1999). Falk stated that the learning process in the museum is directly proportional to the harmony with the identity and personal needs of the visitors. At the same time, he stated that in museums, which are a socio-cultural learning environment, visitors with different cultures and experiences will achieve very different outcomes from each other (Falk, 2016).

With the beginning of the new understanding of museology in the 21st century, the concepts of "visitor, audience, listener, consumer, crowds, partners, participant, user, watcher and customer" emerged (Reeve & Woollard, 2006). It has gained importance to divide visitors into groups according to their learning

experience, interests and individual characteristics (Hooper-Greenhill, 1999a). The experience of the person has gained importance with the viewer's transformation into a "performer" (Karadeniz et al., 2015).

Thanks to their new roles, the museum visitor has improved his skills in synthesis, inspiration, generating new ideas and technology (Karadeniz, 2018). For the continuity of these roles, it is aimed to produce attractive ideas consisting of more entertaining and different learning methods about the effective use of collections and presentation of resources to visitors in museums (Hooper-Greenhill, 1999b).

## Active Learning Methods in Science Museums and Science Centers

According to their collections, museums are divided into sections such as art, science, history and archeology. Of these, science museums frequently use active learning methods in their exhibitions as environments for "experimenting, hypothesising, interpreting and drawing conclusions" (Allen, 2004). It has brought many innovations to the concept of museum by providing the visitor with the opportunity to have fun and experience.

The selected examples within the scope of the study are the Boston Science Museum, which was established in the 1900s and underwent renovation, the Experimentarium, which was founded and renovated in the 1900s, and the Welios Science Center, which was opened after 2000 and operates as a science center. The exhibitions that museums have in different branches of science (physics, biology, etc.) and the senses through which they offer experience to the visitors have been one of the evaluation parameters. Constructivist and experimental aspects of these exhibitions are discussed in the evaluation part.

### *Boston Science Museum - MOS (MUSEUM OF SCIENCE)*

The museum first opened in 1830 as the Boston Natural History Society. In the 19th century it was more commonly known as the Boston Museum of Natural History. In the 1900s, the library and children's rooms were added to its structure and it was renamed as the Science Museum. After World War II, the museum building was moved next to the Charles River and reopened in 1951 as the country's first and comprehensive science museum. It has undergone extensive renovation and enlargement by Fentress Architects in 2013 and 2016. The exhibition halls are named as blue wing, green wing and red wing. The museum contains more than 700 interactive exhibits. This museum also includes the Charles Hayden Planetarium, the Mugar Omni Theatre, a single-domed IMAX screen, 4D cinema and theater stages with live presentations (URL-2).

When the architectural space setup of the museum is examined, a rectangular plan scheme appears. There is a bridge on the upper floors between the blue, green and red wings. There is the main entrance between the red and blue wings and the exhibits are dispersed in both directions. While visiting the exhibitions in the ground floor Blue wing, a full-size “Tyrannosaurus rex (T-Rex)” model of the “Dinosaurs” exhibition can be seen from the gallery space (Figure 2b). Thus, it was possible to arouse the curiosity of the visitors by establishing visual communication between the exhibitions. Again, in the gallery space where the stairs of the blue wing are located, the temporary exhibition area on the basement floor is visible. Other exhibition spaces are located around this gallery space. On the ground floor, the green wing is the temporary exhibition area, while the red wing crossing the bridge contains the Cafe, Planetarium, and Mugar Omni Theater (URL-3).

The second entrance of the museum is in the basement and on the facade overlooking the Charles River. Here is the Yawkey Gallery with interactive information about the river (Figure 2a). There are exhibition areas in all three wings on the basement floor. Among these exhibits are exhibits that tell about the creatures in nature and then contain the secrets of the planet. On the first floor of the museum, the green and blue wings make a circular orientation within themselves and draw a path that takes the visitors around and

back to the bridge (Figure 2c). Visitors who examine human life on the green wing discover the nature of physics with The Light House exhibition on the blue wing.

Additional tickets are required for the Planetarium in the red wing, Mugar Omni Theater and the 4-D Theater in the blue wing, in addition to the exhibition ticket. Shapiro Family and Theater of Electricity live presentations can be visited with an exhibition ticket (URL-3).

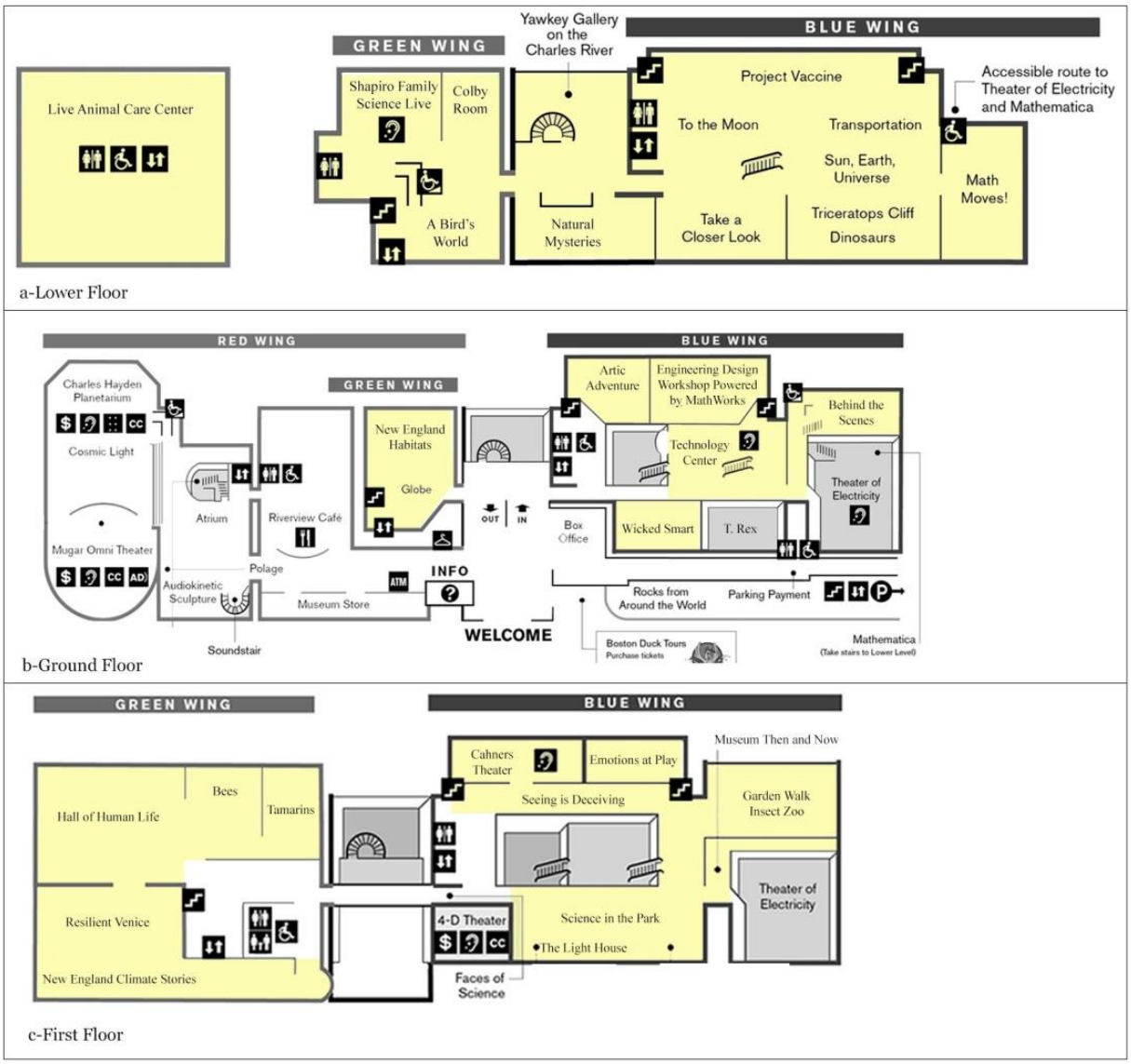


**Figure 2a-2b-2c.** *Museum of science architecture plans, exhibition areas (URL-3)*
*(Exhibition venues are marked by the author with reference to the 2021 plan diagrams on the official website of the museum.)*

The museum has permanent exhibitions on physics, biology, mathematics, archeology, geography and astronomy. Selected examples from these exhibitions and their experiences are conveyed as stated on the official website of the Boston of Science Museum. Afterwards, the following table was created by examining which senses these exhibitions activate (Table 1).

Table 1.
*Boston science museum exhibits, experiences, and senses*

| Exhibitions | Space | Experiences | Senses |
|---|---|---|---|
| New England Habitats | B | You can experience the natural environment of New England by seeing the creatures living in the habitat and hearing the sounds they make. | Sight<br>Hearing |
| The Light House | P | Experience the body being cut into small pieces by walking along a mirrored wall. Experience creating light of any color by mixing the three primary colors of light in different amounts. (Figure 3) | Sight<br>Moving<br>Touch |
| Mathematica | M | Use your body as a unit of measurement by climbing onto a large chair and then squeezing into a small chair. (Figure-4) | Sight<br>Moving<br>Touch |
| The Rock Garden | Archae | Tap the two-ton piece of limestone in the Rock of Gibraltar. | Sight<br>Touch |
| Polar Adventure | G | Observe the scenery and animals that change according to the seasons at the poles, experience the arctic cold by touching the wall from real ice. Try to identify marine mammals by their sounds recorded with an underwater hydrophone. Feel the ice, the sound of cracking ice, and the wind blowing. Experience navigating through a glacier. (Figure-5) | Sight<br>Touch<br>Hearing<br>Moving |
| To The Moon | Ast | Stand in front of the full-size model of the Lunar Module cockpit and observe the lunar boulders. Experience the first Moon landing. (It was being entered before the pandemic) (Figure-6) | Sight<br>Moving |
| Take a Closer Look | S | Experience things that are too fast, too small, too far away, or invisible to the naked eye. See a sound wave; discover hot spots around you with an infrared camera. (Figure-7) | Sight<br>Hearing<br>Moving |

Legend 1: *B: Biology, P: Physics, M: Mathematics, Archae: Archeology, G: Geography, Ast: Astronomy, S: Senses*

**Figure 3.** *Light house (URL-3)*

**Figure 4.** *Mathematica (URL-3)*

**Figure 5.** *Polar adventure (URL-3)*

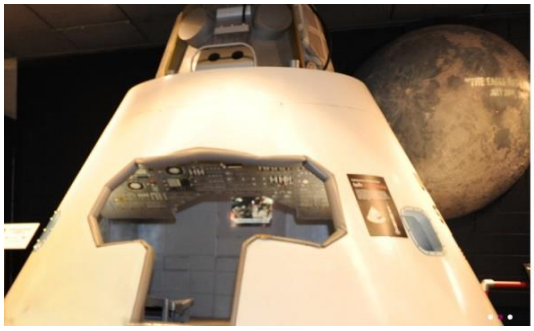

**Figure 6.** *To The moon (URL-3)*

**Figure 7.** *Take a closer look (URL-3)*

### *Experimentarium / Experiment Center*

Experimentarium is an experimental center established in Denmark in 1991. An international competition was held in 2011 to renovate the building. With the project won by the CEBRA architectural firm, the museum was renovated and reopened in 2017. Within the renovation project, new floors, sculptural staircases, and atriums were added to the museum building. In the renovation project, new floors, sculptural staircases and atriums were added to the museum building. The design of the Helix ladder was inspired by the DNA helix structure and is plated with copper. In addition, 16 interactive exhibition spaces, a large rooftop terrace opening to events, staff facilities, a large cafe and picnic area, convention center, educational facilities and workshops have been added. The main theme of the renovated museum has been the sense of curiosity. It aimed to enable children and young people to discover the world we live in (URL-4).

The plan scheme of the museum has a rectangular form. In a wide entrance on the ground floor, the visitor first encounters the sculptural Helix staircase and its gallery space. On the plan walls of the ground floor, technical, administrative and warehouse spaces are located. Helix staircase, on the other hand, has a design that visually connects all floors. The exhibition visited on this floor is The Miniverse (Figure 8a). With this exhibition, a mini-universe where children can have fun and learn first is presented. The second vertical circulation, a glass elevator, passes through this exhibition area to The Beach exhibition on the upper floor.

On the first floor, administrative and indoor spaces are located on the two long sides of the plan scheme, while the large space in the middle is designed as a place where exhibitions can be placed flexibly. The exhibitions, which do not have sharp boundaries with each other, provide a flexible circulation opportunity for the visitor. Continuing the The Beach exhibition, there are different rooms of a house in the exhibition where competitions and games are played as a group with Pulse Plaza. The exhibition, which follows the experiments on the human body, and then The Tunnel of Senses, where the senses are actively felt, are also visited on this floor (Figure 8b). The Beach and The Port exhibitions here, on the other hand, relate to the fact that the museum is located by the beach and aim to learn about its location on the spot. On the second floor, there are flexible exhibition areas located at the center of the plan. Interactive exhibitions consisting mostly of physics, mechanics and mathematical sciences are visited here (Figure 8c).

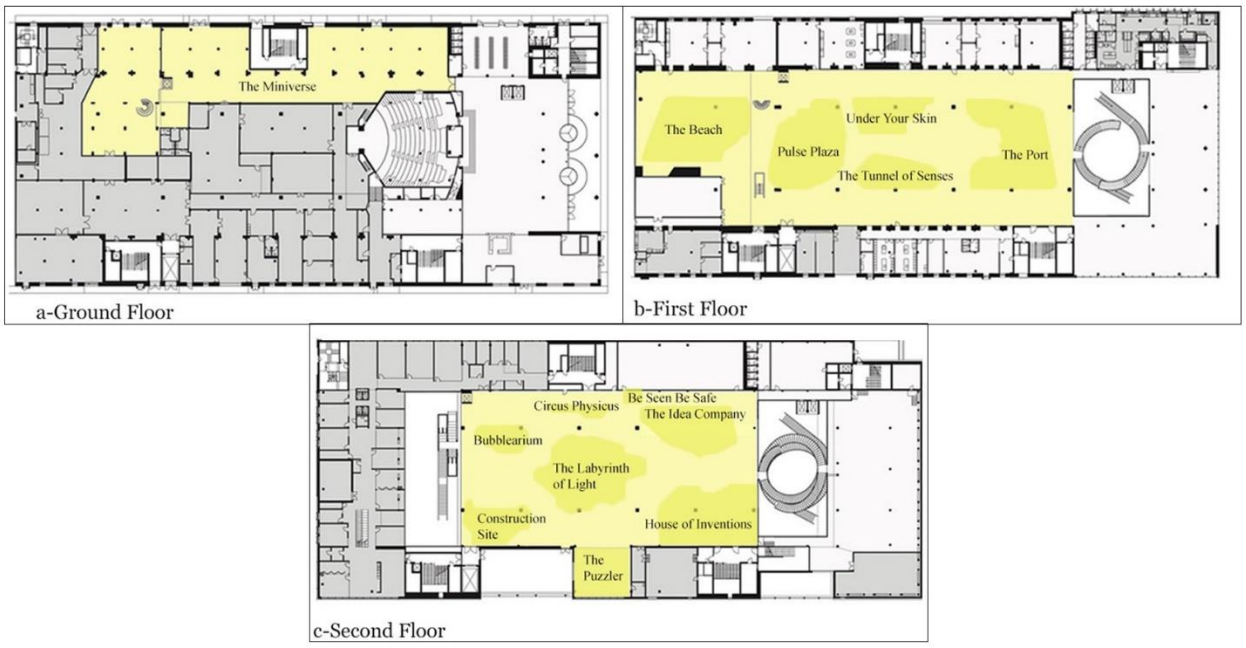


**Figure 8a-8b-8c:** *Experimentarium architecture plans, exhibition spaces (URL-4)*
*(Exhibition venues are marked by the author with reference to the plan diagrams on the official website of the museum.)*

Examples from 16 exhibitions on physics, biology, mathematics, archeology, geography and astronomy in the museum are selected and their experiences are conveyed as stated on the official website of the Experimentarium. Afterwards, the following table was created by examining which senses these exhibitions activate (Table-2).

Table 2.
*Experimentarium exhibits, experiences and senses*

| Exhibitions | Space | Experiences | Senses |
|---|---|---|---|
| Under Your Skin | B | Experience the human body. In the exhibition, it is possible to hear the sounds of the body, to look at a brain in three dimensions, to fight a bad virus in the immune game, and to see one's own body with a thermal camera. | Sight Hearing Touch |
| Bubblearium | P | You can experience making bubbles with your hands, creating lots of soap bubbles using bubble tools, and standing in a soap bubble that you can get into. (Figure-9) | Sight Touch |
| The Puzzler | M | Contains puzzles, logical riddles, geometric jokes, jigsaw puzzles, fun exercises. It is a quiet space where you can solve riddles by yourself. | Sight Touch |
| Construction Site | Mech | You can experience the lift cycle by pedaling, using ball racing, and doing many other activities. At the construction site, you can experience the mechanics with your own body as you spin, pull, and lift the balls, and feel the force of gravity in your stomach as you follow the balls' descent before you start. (Figure 10) | Sight Moving |
| The Port | G | You can experience navigating a large ship. There is a wind tunnel to feel the power of the storm at sea. With the ship simulator, the experience of being a ship captain in the high-sea is realized. (Figure-11) | Sight Touch Hearing |

| | | | |
|---|---|---|---|
| The Miniverse | Ast | By building large foam blocks in Storm Construction, you experience making the most durable structure to be destroyed by the forces of nature and the storm. | Sight Touch |
| The Tunnel of Senses | S | Experience how the senses change from infancy to old age. It is a tunnel journey that allows reflection on the senses of hearing, touch, tasting sight, and smell. | Sight Hearing Touch Tasting Smell Moving |

Legend 2: *B: Biology, P: Physics, M: Mathematics, Mech: Mechanics, G: Geography, Ast: Astronomy, S: Senses*

**Figure 9.** *Bubblearium (URL-5)*

**Figure 10.** *Construction Site (URL-6)*

**Figure 11.** *The Port (URL-5)*

### *Welios Science Center*

Welios Science Museum was designed by the architects Archinauten Dworschak and Mühlbachler ZT Gmbh with the theme of "renewable energy". It is located between the city center and the fairground and acts as an urban center. Visitors reach the entrance hall of the museum under a wide roof. The inner atrium extends to the roof and is lit from above. On the ground floor of the museum, there are foyer, restaurant, gift shop, seminar room, workshop, multi-purpose space and special exhibition areas (Figure 12a). The foyer is used multifunctionally in different combinations for various events. On the first floor, there are offices, open spaces and the upper floor of the restaurant (Figure 12b).

The x-shaped design of the exhibition spaces has been effective in the formation of flexible spaces and in obtaining room arrays of different sizes and features. Thanks to this plan scheme, some exhibits get daylight, while others are inside the shell. Thus, spaces with various sizes and features are formed according to the type of exhibitions. In addition, transparency is provided in terms of visibility thanks to the atrium (Figure 12c) in the exhibition section features (Thematic Museums, 2012). Welios science museum/center has more than 150 interactive exhibits on 3,000 $m^2$, permanent and special exhibitions aimed at learning about scientific subjects through excitement, fun and play. (URL-7). The subject of the permanent exhibition consists of solar energy, hydroelectric, wind energy, geothermal energy, which is the concept of the museum. Within the article, an analysis was made on temporary and special exhibitions.

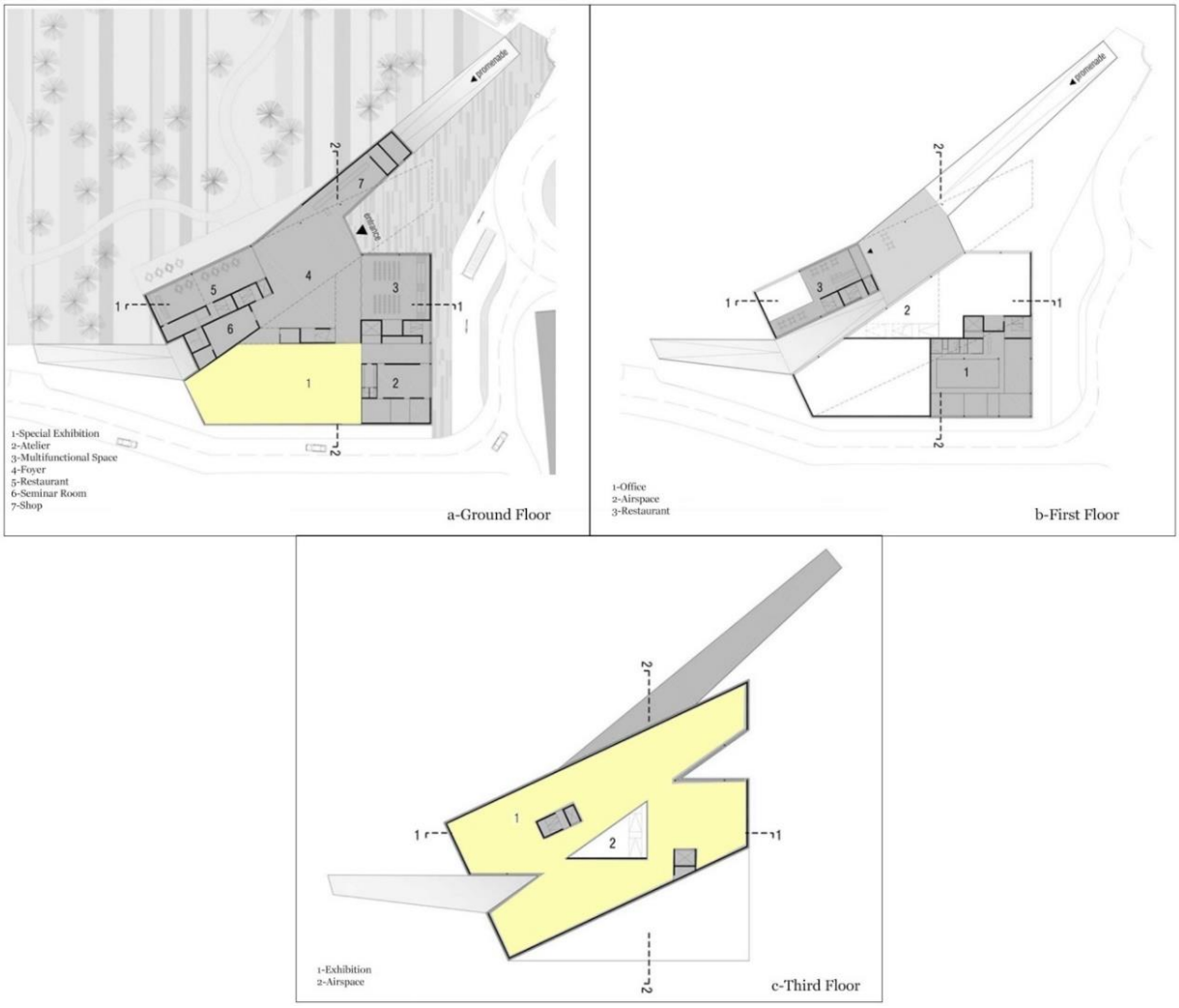


**Figure 12a-12b-12c:** *Welios science center architectural plans, exhibition areas (URL-8)*

*(The locations of the exhibition areas are not specified separately on the Welios Science Center official website. The whole exhibition area is marked as a single area on the author's side.)*

Examples of temporary exhibitions in the museum on physics, biology, mathematics, archeology, geography and astronomy are selected and their experiences are conveyed as stated on the official website of Welios Science Center. Afterwards, the following table was created by examining which senses these exhibitions activate. (Table-3).

Table 3.
*Welios science center exhibits, experiences and senses*

| Exhibitions | Space | Experiences | Senses |
|---|---|---|---|
| Human Experiment - Test Your Body | B | The subject of the exhibition is the human body, health, and nutrition. Try to do the work of your heart muscle yourself. Track your white blood cells. Test your ability to concentrate. Look at your skin with the microscope camera. Test your jumping ability. Watch how muscles and tendons are used. Learn exciting details about health, nutrition, and the human body. | Sight Touch Moving |

| | | | |
|---|---|---|---|
| Light and Color | P | With tiny glass beads, you can create a rainbow for yourself, create clouds or go down to the color of the water. | Sight Touch |
| Applied Mathematics | M | You can build puzzles, build bridges, break the heads while playing puzzles, experience math by standing inside a giant soap bubble. | Sight Touch |
| Special Show: Admiration for Cars and Engines | Mech | What does the inside of an engine look like? Engines and car parts can be disassembled and reassembled under expert guidance at interactive stations. It is possible to get acquainted with the inner workings and tools necessary for this job. "Test your driving license" and test your driving skills. You can expand and test your knowledge of road traffic. Experienced drivers support you and you can even get your "trial license". (Fig. 13) | Sight Touch Moving |
| Under the Clouds | Met | Experience which tools are used to save the weather data and how to get the weather forecast with a virtual tour. | Sight Touch |
| Weightless Space Adventure | Ast | It is possible to explore various constellations. Experience what astronauts feel like doing fine repairs with their thick gloves. You can examine how people are affected and what happens to the muscles in a weightless environment. It can also be experienced with a vibrating headset, running chairs, and simulation of sound animations to experience the rocket capsule. | Sight Touch Moving Hearing |
| The World of Reflections | S | Experience the exciting journey of perceptual illusions in the Illusion Room, which will take you on a journey through the world of optical illusions. (Fig. 14) | Sight Moving |

Legend 3: *B: Biology, P: Physics, M: Mathematics, Mech: Mechanics, Met: Meteorology, Ast: Astronomy, S: Senses*


**Figure 13.** *Admiration for Cars and Engines (URL-7)* **Figure 14.** *The World of Reflections (URL-7)*

## DISCUSSION, CONCLUSION and RECOMMENDATIONS

Constructivist learning, which is one of the active learning methods examined in the article, aims to make sense of information by discovering, discussing and commenting, while experimental learning aims to extract concepts from concrete experiences and gain experience by using the senses. Multi-sensory experience, on the other hand, advocates a learning integrity that appeals to all senses. The finding of these

methods in the literature has had important consequences on the character of the museum, its exhibition method and its relationship with the visitor.

Changes that active learning methods, which have been popular recently, have contributed to museum education,

- The effect of the museum program on the architectural program,
- The reflection of the change in exhibition methods on the architectural space,
- Relationship with the visitor

examined in context.

As a primary effect, it is seen that classical museology has begun the process of transforming into a field of experience. Thus, instead of the information consumed by watching in classical museology, new version museums and centers have begun to emerge, aiming to be reproduced with experiences from which each user draws unique results. Considering the foundation dates of the examples in the article, the Boston Science Museum was opened in 1951 and underwent renovation between 2013-16. The second example, the Experimentarium Experiment Center, was established in 1991 and reopened in 2011-17. The last example, the Welios Science Center, was built in 2011. With the increase in the experimental aspect of the museum, it has been seen that concepts such as "experiment center, science center" have emerged. It is aimed that the examples opened before the 21st century also renew themselves and catch up with the educational and experimental development of the age. These structures, which changed from the museum to the experiment center and then to the science center, became smaller in square meters and started to be built more boutique.

In terms of program and function, museums that adopt an active learning method include new spaces that support learning. As a reflection of this point of view, venues such as workshops, seminar and congress halls, theater stages, libraries, planetariums, and movie theaters are becoming widespread in experiential museums. In addition to these, it is noteworthy that the cafeteria, open spaces, and event terraces that allow visitors to rest and socialize have started to be expanded. The stores added to the museums as another method of establishing a bond between the visitor and the museum transform the museum visits of the visitors into tangible memories with a rich product range.

It aims to make a permanent contribution to the user's cognition through experimentation in controlled, creative and variable exhibition-experiment environments, on scientific subjects that are difficult to understand within the restrictive possibilities and times of official education programs. As an exhibition method, the Boston Science Museum's exhibitions consist of methods for both watching and making experiments. At the Experimentarium and Welios Science Center, the exhibitions are more dynamic and experimental, activating the visitors. The diversity and inclusivity of the exhibition themes and the number of permanent exhibitions are greater in museums. In the Science Center example, on the other hand, a more variable and dynamic display approach has begun to emerge.

When the exhibition themes in all three examples were analyzed according to learning methods, the following results were obtained.

- There are exhibits in science fields such as physics, biology, mathematics, archeology, geography, and astronomy in the Boston Science Museum examined in the study. Experiences that stimulate the senses of sight and hearing are created by both hearing the underwater sounds and seeing the habitat creatures and marine mammals. The exhibits in this museum enable the experimenter to

combine the three primary colors in various amounts and explore the formation of light with the constructivist method. Experimental learning takes place when an individual or team visitors use their bodies as a unit of measurement, using the ratio-proportion, which is the subject of mathematics. While a visit to the polar region is a real challenging experience for a few people on earth, the coldness of the glaciers can be experienced by everyone with the environment created within the exhibition. In yet another exhibition involving the body, the experience of space travel takes place inside a full-size cockpit. In another exhibition, visitors can discover hotspots using the infrared camera themselves and learn the electromagnetic spectrum by experimenting dynamically.

- For those who want to explore the human body at the Experimentarium Science Center, it is possible to fight viruses by hearing the sounds of organs and detecting immunity in a virtual environment. By solving the complex puzzles of mathematics with fun exercises, the experimenter is allowed to make their own interpretations and structure the knowledge. You can create a bubble and experience going into it. By passing into a huge foam bubble, the user experiences the permeability of the substance. Physics issues such as buoyancy, gravity, and weight are experienced with the use of the body in the three-dimensional construction site established in the exhibition area. Visitors who want to get on a big ship, on the other hand, discover the storm power and the buoyancy of the water while sailing towards the open seas as the captain of the ship with the help of a simulator. In another exhibition, visitors learn by structuring the power of static by building blocks strong enough to be destroyed in a storm. Visitors who are still young or children have limited knowledge of aging. With the exhibition that makes people travel through time, they get old for a short time and experience the changes that occur in their senses. Thus, visitors learn by exploring all their senses.

- At the Welios Science Center, participants can undertake the tasks of organs inside the human body. Thus, individuals who move the heart muscle themselves start learning dynamically by doing the information instead of reading it directly. At the same time, the exhibition, which asks the participant to move in order to test the muscles of the body, makes them experience how the tendons work. In the exhibition about light and color, rainbows can be produced with the use of glass bubbles. The mathematics exhibition, which consists of interactive stations, is aimed to learn by having fun, touching, and practicing. Although it is not always possible to see the interior of the vehicles up close, disassembling and reassembling engine parts can be experienced in an exhibition. Thus, it is possible to discover mechanics and learn by practicing. In another exhibition, seeing, touching, and forecasting weather-measuring instruments is experienced with a virtual tour. Seeing the constellations up close in the depths of space can be experienced how astronauts feel by wearing their thick gloves. It is experienced how the body is affected by the space without weight. Launching in a rocket capsule with the help of simulators offers the user an unforgettable space travel experience. Finally, in the exhibition designed to explore the science of optics, an exciting journey experience about illusion is given to the visitors.

In these researched museums and centers, it can be seen that information on different subjects of science has been conveyed to the visitors in a dynamic way with constructivist and experimental learning methods. Thus, since the internalization of information becomes possible, profound effects can occur on visitors. It stimulates the body, the senses, the senses of discovery and curiosity in all three museums to create meaningful experiences. Repetition of museum visits, continuous renewal of exhibitions and experiences

is possible by keeping the curiosity of the audience alive. The museums, which invite visitors again, have a great share in social development as they provide the flow of information by updating.

When examined spatially, it is noteworthy that with the use of active learning methods in museums, changes have occurred in the exhibition spaces. Instead of the cellular structure of the exhibition spaces seen in classical museology, which are separated from each other by sharp boundaries, the examples examined in the article seem to prefer a space design that allows both experimental learning and is flexible enough for the formation of different experimental spaces. Thanks to this plan scheme, visitors can easily see the experiment areas and move in the order that interests them. Likewise, the gallery spaces in the examples also provide visibility between floors and help create a permeable plan. With these innovations in the exhibition spaces, it has been observed that science museums were first referred to as experiment centers and then turned into science centers.

As a result; With the change in the learning method used in museology, radical changes in the museum mission, object and user relationship are striking. As a reflection of this change; First of all, the museum itself has taken on a mission that allows learning, not teaching. These museums have been liberated from the function of protecting, exhibiting and presenting the collection they contain with strict rules. In this way, the visitor, on the other hand, can transform from the position of reading, hearing, passively watching, to touching, feeling, trying, using, creating and participating roles. This change in method has led the museum's position that prioritizes the object/collection towards the approach that prioritizes people. Thanks to new methods, such museums and centers can establish a strong bond with the user, and moreover, they create attraction to be visited again by promising different experiences with their updated programs.

In order to enrich the visitor's experience, the exhibition elements are arranged in a way that activates more than one sense organ. Progress in sound-light-heat-insulation and technology have a great contribution in spatial arrangements that offer real or very close to reality vision, hearing, touch, smell, taste and movement senses as in the examples selected in the research.

Therefor, the density of exhibition spaces has begun to shift towards experimentation, workspaces, and presentation areas of audiovisual-heat systems. Transformable, fluid planning that allows changes supported by advanced technology in museum designs has gained importance. With the opportunities provided by technology, many experiences that are not visible and accessible in daily life will be easily and safely experienced and comprehended in such museums. It is thought that the new task of architecture will be to discover the convenience of the space for experience, instead of producing spaces that present itself.

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**Ethics Committee Certificate of Approval:** Ethics Committee Certificate of Approval was not obtained since no experiment was conducted in the method part of the study and the information obtained was included in the official websites.

**Conflict of Interest Statement:** There is no conflict of interest.

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