MOVEMENTS AND BEHAVIORS IN EXHIBITION SPACES

an exploratory case study in a science center

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Gothenburg, Sweden 2023

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ABSTRACT

Science centers are informal learning environments where the visitors are in charge of their own learning process. This makes exhibition design a complex task that requires knowledge of what attracts visitors to interact with exhibits (and thereby, learn). From previous studies it is known that exhibition design may affect both movement and attention among visitors. However, little is known when it comes to the design of contemporary exhibitions in science centers.

This exploratory case study, conducted at the mathematical exhibition Mathrix at Universeum in Gothenburg, aims at improving the understanding of what affects visitors' movements and behaviors in an interactive exhibition. Based on the three perspectives; design, use and theory, the correlation between the visitors' actual behavior and the exhibition design intentions were examined at both a structural level (layout and composition of exhibits) and an object level (exhibit design).

To retrieve data of the visitors´movements, interactions and exhibit attractiveness, field observations were performed at the exhibition and the visitors were asked to fill out a questionnaire. Thereafter, interviews were conducted with the designers in order to understand their intentions with the exhibition space at both a structural and an object level. The user and design perspectives were then analyzed inductively, with inspiration from the grounded theory method, in order to search for themes and patterns regarding the visitors´ movements and behaviors. The result from the inductive analysis was then compared with a spatial analysis (Space Syntax) at a structural level and with theories of attention and motivation at an object level.

The case study shows that exhibition design is a complex process, with difficulties to predict attraction to specific exhibits. The study also shows that it is not possible to rely solely on theoretical models. Visitors' decisions to interact with exhibits are influenced by the exhibition design at a structural level but also by several factors related to personal, social and physical aspects. These aspects may be more or less conscious.
A three layered model, with personal, social and physical aspects, is formulated in the study (based on the empirical data and motivated by existing theories). The model may be a helpful tool in order to understand these three aspects. It may be used both for evaluation of existing designs but also as a design tool during a creative process. By combining theoretical prediction models such as Space Syntax with the three layered model exhibition, designers can get a better understanding of visitors movements and behaviors.

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Hilda Alfredsson, Gothenburg, June 2023

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1.INTRODUCTION

1.1 BACKGROUND

Science centers are learning environments that aim to attract visitors of all ages and backgrounds, both for educational purposes and as a form of leisure activity (Allen, 2004; Rogoff et al., 2016). Most science centers are built on the idea that visitors learn the most through exploration, research and play. It is the activities per se that are considered positive for the learning process, since it makes visitors stay longer at the exhibits and become more active in their own learning process. John Dewey (1859-1952), who stated "learning by doing" was an influential philosopher in regards to this experiential and interactive perspective on learning.

The informal learning taking place in science centers differs substantially from formal learning taking place in more structured settings, such as classrooms (Macià & García, 2016). Above all, it is the guiding of the learning processes that differs. In informal learning situations there is no teacher or coach with a defined curriculum or learning goal in mind. Instead, the learner navigates the learning process, meaning that it is the individual learner's choice where, when and what to learn (Allen, 2004; Callanan et al., 2011; Rogoff et al., 2016).

Consequently, visitors have a huge impact on, and responsibility for, their own learning process in informal settings. This makes the design of science centers a complex task requiring knowledge of what attracts individuals to interact with different features of the exhibition (and thereby, learn). The way to attract visitors is through attention. Attention may lead to engagement, and engagement is considered necessary for learning (Bobbe and Fischer, 2022). Therefore, most science centers are filled with visual and sound stimuli, and activities to guide the visitors through numerous choices provided.

From previous studies, it is known that visitors' movements and behaviors are influenced by spatial design (e.g. Hillier, 2007; Pen and Turner, 2002). Previous research has also shown that architectural design may influence visitors actions in museum settings (Melton, 1972; Coe, 1985). However, little is known regarding a contemporary science center setting.

When it comes to exhibit design, empirical knowledge is scarce, despite several theoretical models about how visitors learn. In addition, the approach to exhibit design has changed fundamentally over the years, influenced by technical advancements and changes in pedagogic

perspectives (Bobbe and Fischer, 2022). In the past, most exhibits were static and informative but usually not very eye-catching, with signs being the main attractors to get visitors to look at the exhibits (Bitgood et al., 1986). In later years, design elements such as sound and movement have become increasingly utilized (Stocker, 1995), which has been shown to affect visitors' attention (Peart, 1984)(Melton, 1972). However, in contemporary exhibitions in science centers, where interaction is usually the goal, little is known about the influence of exhibition and exhibit design on visitors' attention.

To get a deeper understanding of what affects the degree of exhibit interactions at an exhibition space, it is important to study the visitors movements and behaviors with regards to both a structural level and an object level. In this context, the structural level refers to the room layout and the composition of the exhibits and the object level refers to the exhibit design.

1.2 AIM OF THE STUDY

The aim of this study is to increase understanding of how spatial design influences learning, through observing visitors' movements and behaviors in a science center. More specifically, we explore how people move and behave in the exhibition space and examine what physical exhibit design encourages spontaneous experimentation and activity.

1.3 RESEARCH QUESTIONS

Structural level: *What patterns of movements and behaviors can be identified among the visitors in the exhibition space at a structural level and how do the observed movements and behaviors relate to the designers' intentions?*

Object level: *What makes the visitors attracted to the exhibits (by attracted we mean that they will approach the exhibit and start interacting with it) and how do the findings relate to the designers' intentions?*

Relation between the object level and structural level: *How do the structural and object level influence each other?*

1.4 DELIMITATIONS

The physical exhibition space referred to in the study does not include building physics or physical accessibility. Neither does it include the virtual environment of the digital screens, since the focus was to study visitors' behaviors affected only by the physical design of the exhibition.

The purpose of the study was to examine whether the physical design of an exhibition space influences people to engage with exhibits, since engagement is a prerequisite for learning. However, what the visitors will learn or remember from the exhibition was not studied.

The study explores authentic learning situations, meaning situations where the visitors act on only their own interests and aims. Therefore groups with professional guides are not included in the study.

2. METHOD

2.1 RESEARCH APPROACH

The overall research approach in this study was an inductive approach inspired by the grounded theory method. Grounded theory is a qualitative method that enables the researcher to study phenomena or processes to construct new theories during data production and analysis (Oktay, 2012). The goal with an inductive approach is to search for patterns and associations in the produced data, forming the basis for new theories. In contrast to a deductive approach which is often limited by preconceived methodologies and hypotheses, the inductive approach allows for a more free exploration of the raw data which may lead to new insights. An inductive approach is especially suited for studies in less explored fields and settings (Thomas, 2006), making it suitable for this project. Compared with formal learning environments, studies on informal learning environments are scarce and little is known about the physical conditions for informal learning in science centers, especially regarding the overall structural design in conjunction with details of certain objects.

2.1.1 Research strategy

The research strategy used was a case study, which is a strategy where phenomena are studied in their real-life context (Yin, 1984), and thereby especially suited for this study. It is impossible to study the visitors' behaviors isolated from their environment or study the suitability of a learning environment without the visitors.

2.1.2 Empirical setting

The study was conducted at the mathematical exhibition *Mathrix* at the science center Universeum in Gothenburg. The exhibition, which is solely dedicated to mathematics, opened to the public in the beginning of 2023. The main aim of the exhibition is to attract young visitors, from 13 to 18 years. The exhibition space has an open floor plan with curved interior walls dividing the space into separate sections. The shape of the different sections varies a lot. Also the individual exhibits have a variety of designs both in content and in style. According to a presentation of the exhibition at Universeum's website, the learning environment is divided into four zones: "Jaget", "Världen", "Skapandet" och "Naturen" (roughly translated to "The Self", "The World", "The Creation" and "Nature"). Each theme describes mathematics from different perspectives. In "Jaget" the visitors may explore math related to themselves (e.g. their mood and interests).

In "Världen" and "Naturen" the visitors may explore mathematics that exists in the world around us (e.g. mathematical patterns in nature). In the area "Skapandet" the visitor may create their own music in the "Studio" or practice photography in the photo booth (Universeum, 2022). *Figure 2.1* gives an overview of the exhibition space an the exhibits studied and *Figure 2.2* is a photograph of the entrance area of the exhibition space.

OVERVIEW OF THE EXHIBITION SPACE

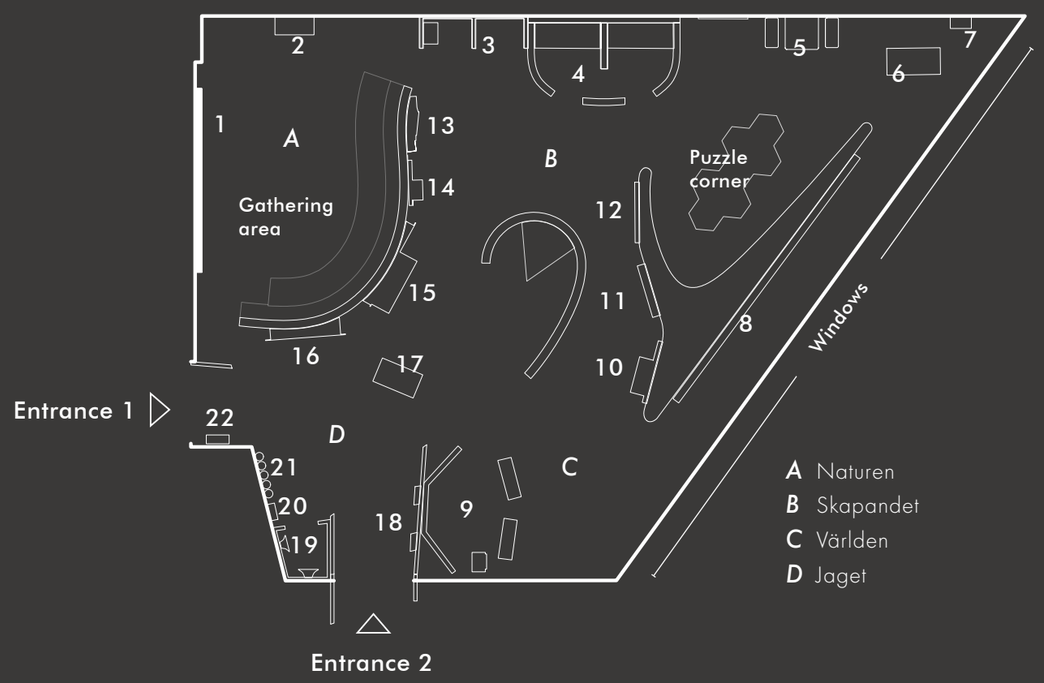


Figure 2.1 *An overview of the exhibition space and the exhibits studied*

EXHIBITS STUDIED

1. Jag som fraktal
2. Voronoi
3. Foto
4. Studion
5. Jaget eller laget
6. Mastermind
7. Nördlig
8. Sifferjakten
9. Världen
10. Vågade ekvationer
11. Derivata
12. Hands on
13. Världen i siffror
14. Klimatsmart
15. Vem vinner loppet
16. Räkna med AI
17. Finder
18. Sant eller falskt 1
19. Matematikskrik
20. Statistiskt korrekt
21. Uppskatta världen
22. Sant eller falskt 2

Figure 2.2 *View of the entrance area of the exhibition space. Showing exhibits 15. Vem vinner loppet, 17. Finder, 20. Statistiskt korrekt and 21. Uppskatta världen*

2.2 DATA PRODUCTION AND ANALYSIS

The data production was conducted at two levels; at a structural level and at an object level. At each level the inductive research approach followed the three stages: 1) data production, 2) search for patterns and 3) development of theories or hypotheses.

2.2.1 Structural level

At the structural level, data was constructed based on two empirical sources: use (field observations), design (semi-structured interviews with the architects and the art director) and from a theory-based spatial analysis (Space Syntax Analysis). The purpose with the field observations was to retrieve information about visitors' behavior in the exhibition. Therefore, observations were chosen, since they can be performed unobtrusively (Webb and Campbell, 1999). The purpose of the interviews with the architects and art-director (from now on referred to as *designers*) was to receive their thoughts and opinions on the design of the exhibition. Therefore, a semi-structured interview method was chosen. It is a qualitative method where the interviewees are asked open-ended questions instead of following a strict list of questions. The interview format also provides possibilities for discussions and follow-up questions (Esaiasson et al., 2017). In line with the grounded theory method, the data of the study was used to explain certain behaviors in the exhibition space.

The quantitative measures from the observations were summarized and compared with the Space Syntax analysis. The qualitative data from the semi-structured interviews and the observations were analyzed thematically. A thematic analysis is the process of identifying patterns and themes in a qualitative data set and it is well suited for inductive studies (Braun and Clarke, 2006). When the inductive analysis was finished the results were compared with the theory-based spatial analysis based on *Space Syntax* (Hillier & Hanson, 1989) (further described in chapter *3.Theory*).

2.2.2 Object level

At the object level, data was constructed based on two empirical sources: use (questionnaire with the visitors) and design (semi-structured interviews with the designers). The questionnaire was chosen since it was considered an efficient way to receive information from the visitors. The questionnaire responses and the semi-structured interviews with the designers were analyzed thematically to search for themes and patterns

in the dataset. When the inductive analysis was finished the results were compared with the theories of *selective attention* described by Driver (2001) and *extrinsic and intrinsic motivation* described by Ryan and Deci (2000) (further described in chapter *3.Theory*).

2.3 PROCEDURE OF THE DATA PRODUCTION

The procedures of the data production are described in the order they were conducted. First the observations and questionnaire, then the interviews with designers and finally the spatial analysis. It was important that the data construction was carried out in this order to minimize the risk of influencing data retrieval from the users (in line with the grounded theory method). In order to gather as much user data as possible, the data from the users´ perspectives was received during a week of school holiday, when a large number of individuals from the exhibition target group were expected to visit Universeum. *Figure 2.3* is an overview of the methods used for the data production.

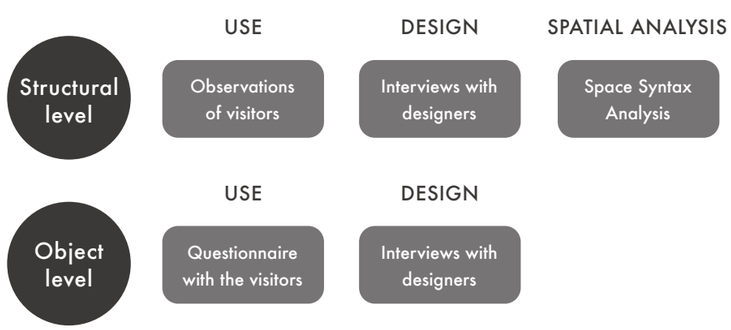


Figure 2.3 *Overview of the methods used for data production*

2.3.1 Use (field observations)

During the structured observations, quantitative measures of frequency were collected. The following behaviors were observed and counted for, each time a visitor:

p = passed (passed the exhibit without watching or interacting)

w = watched (watched the exhibit but did not interact)

i = interacted (interacted with the exhibit, i.e. touched or started the activity at the exhibit)

Each exhibit visitor was only recorded for one of the alternatives above. That means, an exhibit visitor who *interacted (i)* with the exhibit was not also recorded as having *watched (w)* the exhibit.

Visitors of all ages were observed at the 22 exhibits in the exhibition space. These observations were conducted during two days and during the observations the exhibition space was divided into nine sections containing 2-3 exhibits each. Each section was observed during four cycles of 10 minute sessions spread out over two days. During each 10 minute session the observer was standing at a position providing a comprehensive view of the exhibits intended to observe (see *Appendix A* for the division of the space). Since the amount of visitors varied over the time of the day, the order in which the observations took place was changed the second day. The documentation was made with pen and paper (see *Appendix B* for the observation protocol).

The documentation was later transferred from the physical observation sheet to a spreadsheet in order to generate statistics of the percentage of visitors passing, watching or interacting with different exhibits. The statistics were then visualized on the floor plan drawing where the exhibits were colored based on the percentage of people passing/watching/interacting (e.g. exhibits with many visitors interacting were colored red and exhibits with few interaction were colored in blue).

In addition to the structured observations, field notes of qualitative character were collected as a complement during the whole week of data production. The field notes described visitors movements and behaviors in relation to both the structural level and object level of the exhibition space. Aspects of specific interest were e.g., which areas that were the most and least crowded, how the visitors behaved in different areas of the room, if the visitors finished the exhibit activities, if the visitors seemed confused and if some activities made visitors stay for longer periods.

2.3.2 Use (questionnaire)

The questionnaire consisted of four questions in total: three questions about the user characteristics (age and number of visitors in the group, and the relation between the group members) and one question regarding why the visitors chose to interact with the exhibit (see *Appendix C* for the questionnaire). The questionnaire was conducted digitally on a touchpad and the visitors were allowed to ask the researcher questions along the way if something was unclear. The visitors/groups of visitors who were asked to participate were those who had interacted with the exhibit.
To see who approached the exhibit the researcher stood at a position that provided a comprehensive view of one exhibit at a time. When approaching the group, the researcher chose the adult or teenager who had first approached the exhibit and invited that person to participate in the study. If they agreed, they started the procedure of responding to the questionnaire. If they declined, the process was repeated and a new visitor or group of visitors was selected. The visitors were allowed to respond to the questionnaire as a group. However, larger organized groups such as school classes were not included.

The selection of exhibits to study further was based on the results from the structured observations. Striving for a large amount of data from visitors interacting at the exhibits, the selected exhibits had both a high number of visitors attending and interacting, as well as a low number of visitors watching the exhibit without interacting with it. The exhibits chosen to study further were those that fulfilled a predefined criteria based on four aspects. The chosen exhibits should score above average on the following aspects:

1. The overall number of visitors who passed, watched or interacted with the exhibit (=exhibit visitors)
2. The number of exhibit visitors who watched or interacted with it
3. The proportion of exhibit visitors who interacted with it

and below average on the following:

4. The proportion of exhibit visitors who watched but did not interact with it

The data from the questionnaire was collected in a digital form. The user characteristics (quantitative measures) and the open-ended question regarding what made the visitors approach the exhibit (qualitative measures) were separated for further analyses.

2.3.4 Design (semi-structured interviews)

The semi-structured interviews with the designers resulted in data with a qualitative character. An interview guide containing three sections was used during the interviews:

1. Their role in the project
2. Their intentions with the structural level of the exhibition
3. Their intentions with the object level of the exhibition

Regarding the general structure of the exhibition, the following aspects were of interest: the shape and layout of the exhibition space, zones in the room, intentions of activity levels in different areas, the grouping of exhibits, intended visitor movements in the space, etc. Regarding the detailed design of the exhibits, the following aspects were of interest: the shape of the exhibits, graphical layout, colors and materials, visions or thoughts on what would catch interest and engagement, etc. (see *Appendix D* for the complete interview guide). In addition to the verbal descriptions from the interviews, a written pitch regarding the architects design intentions was also received. In total, three interviews were conducted, two of them were on-site at the exhibition space and one was held digitally (due to logistical reasons). For the interview conducted digitally, a drawing of the exhibition space was used in order to facilitate the discussion. The interviews were audio recorded and transcribed. To simplify comparison of the results, the transcribed interviews were divided into the two categories; structural and object level.

2.3.5 Spatial analysis

The spatial analysis based on the Space Syntax theory was conducted in the program DepthMapX (Penn and Turner, 2022). The purpose with the analysis was to get an understanding of the visibility and movement flow in the exhibition space, based solely on the shape of the room and the interior walls. The following analyses were conducted:

- *Visual graph analysis (VGA):* measures the visibility in different areas of the space.
- *Visual depth:* how many "visual steps" you need to take from a certain location in order to see all locations in the space.
- *Visual integration:* measures how visually deep a location is in relation to all other locations in the space.
- *Agent based model:* shows a predicted movement flow in the room based on simple movement rules from the visual graph analysis (i.e. what is visible).

The results of the analyses are presented on a floor plan drawing using a spectral color range; red, orange, yellow, green and blue, where red indicates a high level of visibility or movement and blue indicates a low level of visibility or movement. Further descriptions about the Space Syntax theory is described in chapter *3.Theory*.

2.4 DATA ANALYSIS

The data constructed at each level were analyzed separately, first at the structural level and then at the object level. When the separate analyses were finished the results were compared in order to better understand how the two levels influence each other.

2.4.1 Structural level

There were four types of data analyzed at a structural level: measures of frequency (empirical observations), field notes (empirical observations), transcribed interviews (design intentions at a structural level), and data from the Space Syntax analysis (theory based). The quantitative measures from the empirical observations (i.e measures of frequency or percentage of visitors passing, watching or interacting with an exhibit) and the data from the Space Syntax analysis (visibility and movement in the space) are both presented with different colors on the floor plan drawing. The drawings, based on the two sources, were compared in order to see how the movement flows differ between a room with empty walls and a room filled with stimuli (e.g. lightning, colors, sounds). The semi-structured interviews were analyzed thematically in order to search for the designers' intentions with the space at a structural level, e.g. intended movement and interactions (the thematic analysis is further described in section *2.5.2 Object level*). The result from the thematic analysis was compared with the colored floor plan drawings from the empirical observations and the theory-based analysis. Finally, the field notes were used as a complement to support the analyzed data from the other three sources.

2.4.2 Object level

Two types of data were analyzed at an object level: questionnaire responses (why visitors approached an exhibit) and transcribed interviews (design intentions at an object level). These were both analyzed thematically in the program Nvivo in order to search for themes and patterns regarding the exhibits´ attractiveness. The visitors' responses

were analyzed first and when codes and themes for these had been generated, the data from the semi-structured interviews were added to the same project. Braun and Clarke (2006) describe the thematic analysis as a process in six steps. During the first step the researcher is supposed to become familiar with the data by reading through the material several times. At this stage, it is useful to take notes of spontaneous impressions of the data. The second step is to generate initial codes of the data by organizing and grouping the material in a systematic and meaningful way. In this study, open coding was used which means the codes were developed and modified during the coding process (Walker and Myrick, 2006). The third step of a thematic analysis is to search for themes within the data by grouping the codes that fit together. In the fourth step, the themes and codes are reviewed and modified to make sure that they are coherent and distinct from each other. During the fifth step of the analysis the essence of the themes are reviewed and refined. The sixth and final step of the thematic analysis involves selecting the themes that are related to the research question. The themes that do not relate to the overall aim of the research may be skipped. The themes identified were then compared with previously presented theories.

2.5 ETHICAL CONCERNS

During the observations and in the questionnaire, the only personal information recorded was how the users in the group were related and if the users were included in the target age group or not. This limited information was not considered sensitive, since it could not be used to identify a specific individual. The visitors were informed about the ongoing observation through a sign explaining the purpose of the study at the entrance of the exhibition space. During the questionnaire, visitors' consent to participate in the study was requested. If children under 15 years old participated, their legal guardians were asked for consent to participate, in line with the Act on Ethical Review of Research about People (2003).

The designers were informed about the purpose of the study before they agreed to participate in the interviews. When the interviews were transcribed, the audio records were deleted to make sure the data could not be connected with the respondents. The architects' consent was also received to use their floor plan drawing as a basis for illustrations in the project.

3. THEORY

This chapter presents the theories which the results at the structural and object level are compared with.

3.1 STRUCTURAL LEVEL: SPACE SYNTAX THEORY

Throughout history, there have been many studies looking at how spatial design and architecture influence human movements and behaviors. An influential theory and analytic framework used at both large and small scales is Space Syntax, which was introduced in the late 1970s (Hillier & Hanson, 1989). Over the years, Space Syntax has been further developed. Today the theory is the base of several digital tools that help researchers and designers to analyze and predict movements and behaviors in cities, buildings or rooms. Space Syntax can be used both as a design tool and as an evaluation tool. Over the years, the theory and analytic framework has been applied on interior spaces, such as offices and museums (e.g. Hillier, 2007; Hillier and Tzortzi, 2006). However, it is less used in smaller settings such as a single exhibition room. According to the theory, there is a correlation between visibility in a space and pedestrian flows (Hillier, 2007; Penn and Turner, 2002). Therefore, several Space Syntax measures are based on what is called an isovist, which is a geometric visualization of what a person can see from a certain point in space (Benedikt, 1979; Turner et al., 2001). When a person walks through a space the shape of the isovist changes.

Space Syntax was chosen for this study because it is a theory that investigates the correlation between spatial design and human behaviors, which is the topic of this study. Space Syntax analysis is often used together with empirical observations, which was done in this study as well. The following analysis methods were conducted in this study: *visual graph analysis*, *visual step depth, visual integration*, and a predicted movement analysis called *agent based modeling*.

Visual graph analysis (VGA): A visual graph analysis shows the intervisibility of a space, which is defined as how much of the space that can be seen from all other points in the space (Turner et al., 2001; Turner, 2001). By dividing the space into a grid of small tiles, all visual connections between them are computed and each tile (or a central point of the tile) is assigned a value based on its degree of visibility from all other tiles. The result is presented on a floor plan map using a spectral color range; red, orange, yellow green and blue where red is the most visible (from most other places) on the map and blue is the most hidden.

Visual step depth: The visual step depth of a given location on the floor plan is the "visual steps" required to go from the given location to all other points on the floor plan. The first visual step corresponds to an isovist from a certain location. The second visual step is taken when a path crosses the boundary of the visible space from the previous visual step. *Figure 3.1* shows a visualization of visual step depth of a defined space.

Visual integration: The mean visual step depth from all locations in the space may be visualized in what is called a visual integration graph. A poorly integrated location (also called segregated), colored in dark blue, is deep in relation to all other locations. This means you need to take several visual steps before you see it. A well-integrated location, colored in red, is shallow in relation to all other locations in the space. This means you will need few visual steps to see the location (Turner, 2004).

Agent-based modeling: An agent-based model refers to a computer simulation that depicts the randomized movement based on simple movement rules. In this model, agents select their preferred direction of movement using a defined visual field obtained through the VGA (Penn and Turner, 2022). With an agent-based model, it is possible to simulate how people are likely to behave as they move through an environment. However, the measures and visualizations of the agent-based analysis are solely configurational which means that they take no account for other kinds of stimuli in the space. Neither do they make assumptions about destination or path planning.

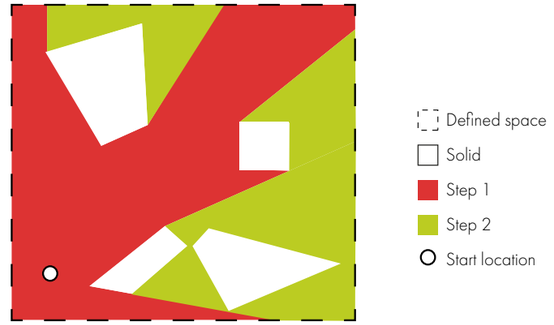


Figure 3.1 *Visualization of visual step depth. The red area shows what is visible from the black point. The yellow area shows what is visible from the red area. In other words, from red to yellow you reach deeper in the defined space.*

3.2 OBJECT LEVEL: ATTENTION & MOTIVATION

Based on the thematic analysis of the visitors' responses to the questionnaire and the interviews with the designers, a list of attractiveness factors regarding exhibits were identified. In order to better understand these factors, the perception theory *Selective attention* was used as an explanatory model.

Selective attention refers to the process of directing our focus on particular stimuli, while ignoring the rest of the environment. Selective attention describes the mechanisms controlling what we pay attention to when we receive information. There are two mechanisms for this selection; *bottom-up attention* and *top-down attention* (Driver, 2001; Katsuki and Constantinidis, 2014). The bottom-up attention is a quick and reactive mechanism driven by external stimuli, such as salience. Salience refers to the perceptual quality that captures an observer's attention towards a specific object. Objects with high salience are those that stand out in relation to the objects in its surrounding. The following factors may influence salience: color, size, contrast in relation to its background, lighting, isolation, etc. Characteristics such as moving objects or animation can also affect salience. The top-down attention on the other hand, is a slow and goal-directed mechanism influenced by the visitor's motivation. For studying this mechanism, the observer's expectations or intentions play a crucial role in determining where attention is directed. Therefore, to fully understand the top-down mechanism a theory behind motivation is needed.

There are many theories that try to describe the motivation behind why people behave the way they do. In this study, a division between *intrinsic and extrinsic motivation* (Ryan and Deci, 2000) was applied, because it is a well known way to describe different types of motivation. Moreover, it was relatable to the attractiveness factors identified in the thematic analysis of the questionnaire responses and the semi-structured interviews. When a person is intrinsically motivated, his/her actions are triggered by an internal will to do something. It means that the learner strives for the goal because of pleasure or stimulation the goal provides. The activity in itself may also be the goal (rather than the outcome of the activity). For example, a person that spends a lot of time practicing a certain skill because of the joy of using the skill, is intrinsically motivated. When a person is extrinsically motivated, his/her actions are triggered by external factors, e.g. rewards by winning a game, getting a high ranking or being praised by other people, or by a risk of a negative outcome.

4. RESULTS AND ANALYSIS

The results in this study are presented at two levels, the structural level and the object level. At the structural level, data from two empirical sources are presented: design (interview responses) and use (field observations), and from a theory based spatial analysis (Space Syntax). At the object level, the results describe two empirical sources: design (interview responses) and use (questionnaire responses). At both levels, the designers' intentions are presented first, followed by the use perspective and then (for the structural level) the spatial analysis. The reason why the results are presented in a different order than the data production is that the results from the field observations and the spatial analysis are structured in a similar manner. They are therefore more easily understood if they are presented together. Before presenting the result at the structural and the object level, the user characteristics are presented.

4.1 USER CHARACTERISTICS

The number of visitors observed ranged from 50 to 170 per exhibit. The questionnaire contained responses from 121 visitor companies (groups or individuals). Both the observations and the questionnaire showed that the most frequent type of company at the exhibition was a group consisting of one or more adults (>18 years) and one or more children (<13 years), typically a family (*Figure 4.1 top image*). Only 20 % of the companies included visitors in target group (*Figure 4.1 bottom image*).

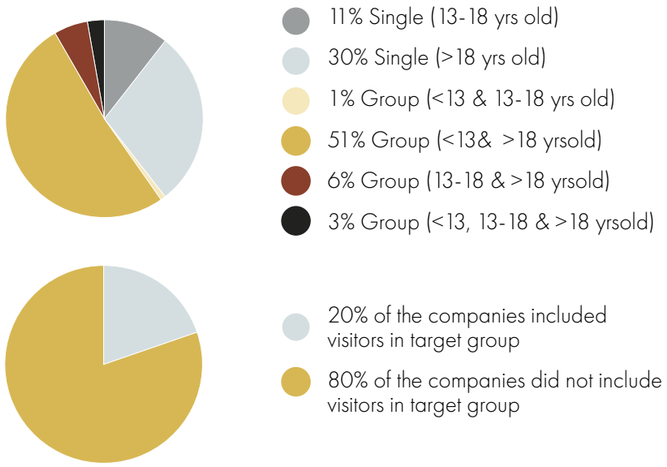


Figure 4.1 *Top image: Age distribution of the groups/individuals responding the questionnaire. Bottom image: The proportion of visitors or groups responding to the questionnaire that included visitors from the target group*

4.2 THE STRUCTURAL LEVEL

The results and analyses in this section are based on the designers' descriptions of their design intentions with the layout and the composition of exhibits, the empirical observations of the visitors movements and behaviors, and the spatial analysis of visibility and movement in the space.

4.2.1 Design (interview responses)

The designers described two design intentions regarding the structural level of the exhibition space: *I) Zones by activity* and *II) Dynamic flow to maintain a joy to discover.*

I) Zones by activity

There were three types of zones described: one calm zone with possibility to sit down and do longer activities, one active zone for movements and shorter exhibit interactions, and one zone for running (dedicated to one specific exhibit). The calm zones were placed in the corners of the room. The zones dedicated for movement and shorter exhibit interactions were the spaces right by the entrances and in the middle of the room. The area intended for running was placed along the window (the right side of the floor plan). In line with the intention to create zones by activity, the designers mentioned that they had placed some exhibits that are faster to finish in the center and some activities that hold the visitors for a longer period in the corners. *Figure 4.2* shows photographs of the calm zones in the exhibition, *Figure 4.3* is a visualization of the architects intentions and *Figure 4.4* also shows that they have placed seats in the calm zones.

"... the further you reach into the exhibition space the calmer it should get, both in the gathering area and by the puzzle corner..." (one of the designers).

II) Dynamic flow to maintain a joy to discover

Despite the small size of the exhibition space, the designers had the intention to give the visitors a feeling of discovering new things behind every corner they pass. The primary design choice to achieve that was to use what they called a curved plan (i.e. the interior walls have a rounded shape) giving the visitors several smaller areas to discover over time instead of one large at once. They also explained that there was no specific path for the visitors to take. Instead there were several routes to reach the same areas of the room, with the intention to let the visitors experience the exhibition on their own.

"... what we thought was exciting with this curvy plan was that it gets more dynamic, you don't see everything at once..." (one of the designers).

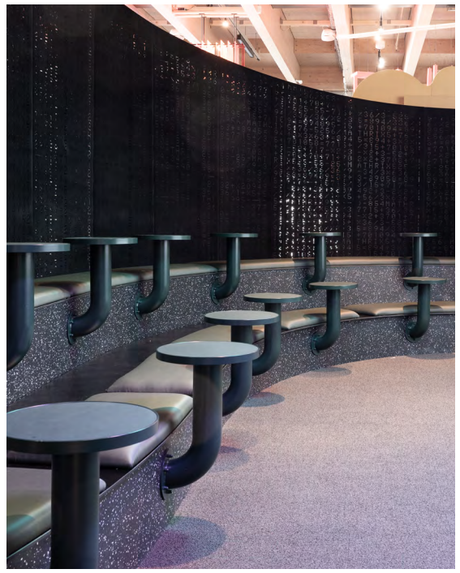


Figure 4.2 *The calm area of the exhibition space. Top image: the puzzle corner. Lower left image: the gathering area. Lower right image: seating area at the area "Världen".*

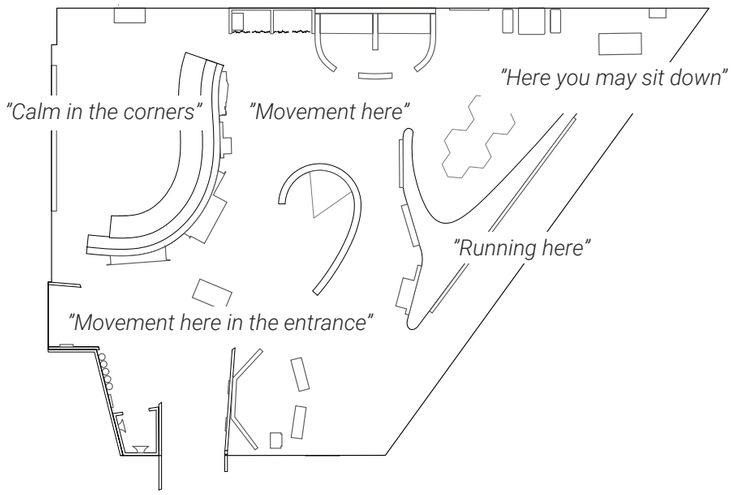


Figure 4.3 *Sketch of designers' intention of zones by activity*

Figure 4.4 *Distribution of seats in the exhibition space*

4.2.2 Use (field observations)

The empirical observations of the visitors' movements and behaviors in the exhibition space were analyzed with three measures; movement analysis, attention analysis and interaction analysis.

I) Empirical movement analysis

The movement analysis (*Figure 4.5*) shows the most and least attended areas, irrespective of if people were only passing, watching or interacting with an exhibit. In other words, where people dwelled in the exhibition space. The results show that a majority of the visitors in the exhibition space moved along a path in the center of the room. The results also show that the central part of the exhibition space was more frequently used by the visitors than the corners of the room. These findings were supported by the field notes that indicated little flow of visitors in the three corners opposite to the entrances, especially in the gathering area (the upper left corner on the floor plan drawing).

II) Empirical attention analysis

The attention analysis (*Figure 4.6*) shows the number of visitors who watched or interacted with an exhibit in relation to the total number of exhibit visitors (($w + i$) / ($p + w + i$), where *p= passing, w = watching*, *i = interacting*). In other words, the percentage of visitors who paid attention to the exhibit when passing it. The results show that exhibits in the gathering area (upper left corner on the floor plan drawing) and the running area (right side) have the highest number of visitors watching or interacting in relation to their number of exhibit visitors. The results also show that the exhibits at the entrance had a low number of visitors watching or interacting in relation to their total number of exhibit visitors.

III) Empirical interaction analysis

The interaction analysis (*Figure 4.7*) shows the number of visitors who interacted in relation to the number of visitors who watched or interacted (i / ($w + i$), *w = watching, i = interacting*). In other words, the percentage of visitors who interacted with the exhibit when they had seen the exhibit. The results show that half of the exhibits studied got an interaction rate at 50% and five exhibits got an interaction rate at less than 30%. The exhibits with the lowest interaction rate could be found at the entrance, in the lower right corner and at the upper right corner.

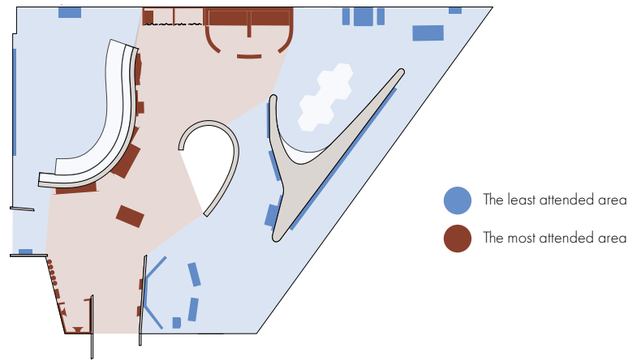


Figure 4.5 *The movement analysis shows the areas with the least and most number of exhibit visitors.*

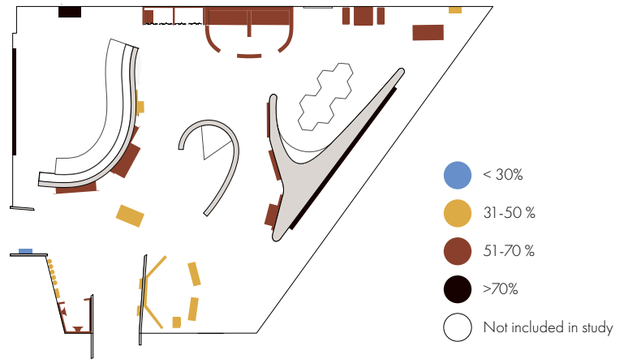


Figure 4.6 *The attention analysis shows the number of visitors who watched or interacted with an exhibit in relation to the total number of exhibit visitors.*

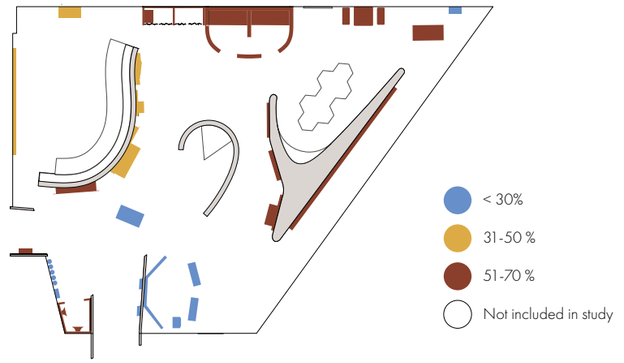


Figure 4.7 *The interaction analysis shows the number of visitors who interacted in relation to the total number of visitors who watched or interacted.*

4.2.3 Theoretical model (Space Syntax)

The spatial analysis resulted in a visibility analysis and a predicted movement analysis of the exhibition space. The Space Syntax analysis is driven by architectural features and not the attractiveness of specific exhibits.

I) Visibility analyses

The visual step depth (*Figure 4.8*) shows what is visible from each entrance and how many "visual steps" it takes to reach all areas of the exhibition. A first visual step corresponds to what is visible from the entrance and a second visual step corresponds to what is visible from the first visual step. In other words, the red area shows what is visible from the entrances, the yellow area shows what is visible from the red area and the blue area shows what is visible from the yellow area (i.e. from red to blue you will reach deeper into the exhibition space). From the left entrance (when looking at the floor plan drawing) the deepest area is the gathering area (in the upper left corner) and from the bottom entrance the deepest area is the running area (on the right side) and parts of the puzzle corner (in the upper right corner).

The visual integration graph (*Figure 4.9*) shows the mean visual depth for all locations in the room. The map indicates that different locations of the room have different spatial visibility hierarchy. There are both relatively segregated spaces and more visibly accessible spaces. The visibly accessible spaces are colored in red and the segregated spaces are colored in blue. The most segregated areas are the gathering area and the long running path along the window. The most accessible areas are the central parts of the room.

II) Agent-based model

The agent-based model shows a predicted movement pattern (*Figure 4.10*) with a relatively high flow of visitors in all parts of the room, except for the gathering area and parts of the running area. The highest flow of visitors is predicted to be in the central parts of the room and the lowest flow of visitors is predicted to be in the three corners opposite to the entrance, especially in the gathering area in the top left corner. However, the visualization of the predicted movement does not take into account what is attractive in the space and makes no assumptions about destination or path planning.

Figure 4.8 *The visual step depth from each entrance. The red area shows what is visible from the entrances. The yellow area shows what is visible from the red area. The blue area shows what is visible from the yellow area. In other words, from red to blue you reach deeper in the space.*

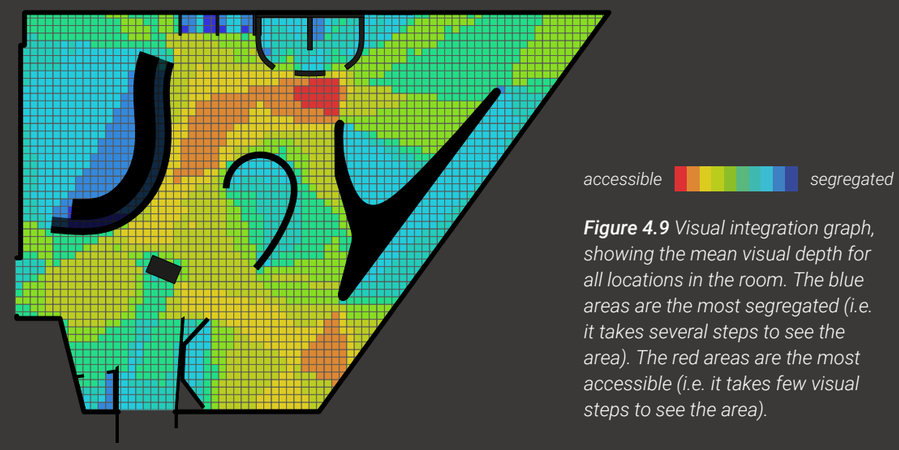


Figure 4.9 *Visual integration graph, showing the mean visual depth for all locations in the room. The blue areas are the most segregated (i.e. it takes several steps to see the area). The red areas are the most accessible (i.e. it takes few visual steps to see the area).*

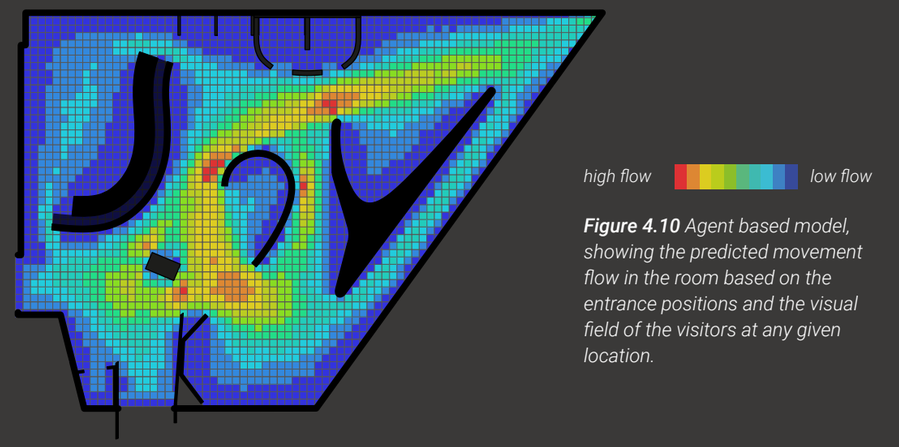


Figure 4.10 *Agent based model, showing the predicted movement flow in the room based on the entrance positions and the visual field of the visitors at any given location.*

4.2.4 Analysis: the structural level

The empirical observations and the Space Syntax analysis both support the designers' intent of *zones by activity*. The field observations show that there were few visitors dwelling in the corners of the room, while the central parts of the room showed a higher visitor flow. The Space Syntax analysis showed that the design of the wall shapes generates less movement in the corners of the space.

The Space Syntax analysis indicates that the architecture of the room including the interior walls also support a *dynamic flow* in the room, with high movement flows along several paths in the central areas of the room. However, according to the empirical movement patterns (*Figure 4.5*), a majority of the visitors walked along a narrow path in the center of the exhibition. A possible explanation of the differences in our findings may be that the visitor flow was higher through the bottom entrance (when looking at the floor plan drawing) during the empirical observation, while the visitor flow was equal from both entrances in the Space Syntax analysis (*Figure 4.10*). The visitor flow shown in the empirical observations is similar to the first visual step from the bottom entrance (*Figure 4.8* left image).

Further analyses regarding visitors´ movements and interactions are discussed in section *4.4 Analysis: the structural and object level.*

4.3 THE OBJECT LEVEL

The results and analyses in this section are based on the designers' descriptions of their intentions with the exhibit designs and the exhibit visitors' responses to the questionnaire regarding what made them approach a certain exhibit.

4.3.1 Design (interview responses)

The designers described three main intentions with the exhibit design. These are described under the following headlines: *I) Global associations or more expressive elements, II) Appearance of activity* and *III) Local consistency*. In addition, the designers discussed the social situations that may appear in the room, these are presented under the following headline: *Reflections on social influences.*

I) Global associations or more expressive elements

The designers described that the aim of the exhibit design in many cases was to make visitors associate with either the main topic of the exhibit (i.e. mathematics) or the specific exhibit theme. The designers described that their intention was to be explicit in their design communication, a curve for the "Derivata" exhibit, hands for the "Hands on" exhibit and so on. In addition, the smiley symbol was something that appeared at many of the exhibits (and at other places in the exhibition space) because it was simply thought to make people happy. However, the designers also mentioned that some design elements, e.g. eye-catching colors (which many exhibits had) were not specifically associated with the theme of the exhibit but generally thought to draw attention. Accordingly, exhibits that were difficult to associate with a topic had more expressive design elements (colors, sound, visualizations etc.) than those easily related to a certain topic. For example the exhibit "Studion" had a less expressive visual design, because the designers thought the topic (music) would speak for itself.

II) Appearance of activity

Apart from the physical shape of the exhibits, one of the designers mentioned the importance of visitors being able to see the activities going on at the exhibits. Above all, they highlighted the importance of interactivity at the exhibits and their belief that exhibits shaped as rooms would attract visitors to interact.

III) Local consistency

The designers had an intention to create local consistency in the exhibition space in order to make the visitors feel comfortable despite all the new impressions. One way to achieve this was to use the same text layout and text style at all exhibits (labels in one style, introduction in one style and so on).

Reflections on social influences

The designers did not point to any specific design intention regarding social interactions in the exhibition. However, they discussed the possibility that a visitor may wish to see someone else doing an activity before themselves but also a possible fear of performing an activity when others are watching.

4.3.2 Use (questionnaire responses)

The exhibit visitors' responses responses regarding why they approached the exhibits were categorized into personal, social, physical aspects, presented in *Table 4.1*. In addition to these three categories of aspects several responses were also general, describing a certain feeling that made them approach, e.g., spontaneity, excitement and interest.

Table 4.1 *Analysis of the exhibit visitors' responses*

PERSONAL	Learning opportunities	Personal connection
	Learning goals *it was what you learn by doing the activity at the exhibit that attracted the visitors. E.g. "Images, learn to take good images." or "Interesting with AI and new technologies".* ***Knowledge level****: visitors had previous knowledge of the exhibit subject. E.g. "Father is mathematician" or "We have studied music".*	***Personal interest****: exhibit subject was related to the visitor's own interests. E.g. "An interest for music" or "I like photographing".* ***Concern for others****: visitors thought the exhibit would suit someone else's interests. E.g. "Thought it would suit a 5-year old"* ***Predetermined plan****: visitors had a plan in advance for which exhibits to look at. E.g. "Was the one that was next" and "look at most exhibits"*
SOCIAL	Behavior	Situation
	Sense of belonging (external)*: visitors saw people in other companies at the exhibit activity. E.g. "Saw other people using the exhibit before us" or "Other visitors tried it before me"* ***Sense of belonging (internal)****: visitors followed people of their own group E..g. "Followed my children" or "The child guides me"..*	***Availability****: visitors approached the exhibit based on what was occupied and not. E.g. "It was free" or "It was empty".*
PHYSICAL	Specific design element	Apperance of activity
	Color*: the exhibit had an eye-catching color* ***Moving visualization****: a moving visualization at the exhibit attracted* ***Light****: the exhibit lighting attracted* ***Name****: the name of the exhibit attracted* ***Sound****: digital sound or sound from other visitors attracted e.g. "heard other people scream"* ***Association****: the shape of the exhibit was associated with a certain topic. E.g. "We thought it was a photobooth" and "Looked exciting with a piano".*	***Outcome/results****: what you get from doing the activity at the exhibit was what attracted the visitors. E.g. "Interesting to see how it measures age and reaction"* ***Interactivity****: the exhibit had buttons or other physical attributes that encouraged interactions.* ***Gamification****: the fact that the exhibit was designed as a game attracted the visitors.* ***Spatial privacy****: exhibits shaped as rooms attracted the visitors. E.g. "The father saw a room and thought it seemed exciting that you could walk into it" and "There was a curtain that hid the attraction which made us curious"*

One way to understand and to visualize the visitors' responses regarding why they approached the exhibits is to look at them as three layers: personal, social, physical (see *Figure 4.11*). The personal layer may be seen as the layer that filters the input and directs the visitors' behavior. The social and physical layers, in their turn, characterize the external stimuli that may act as triggers or barriers to the personal layer. The responses that were categorized as general may be based on any of these three layers.

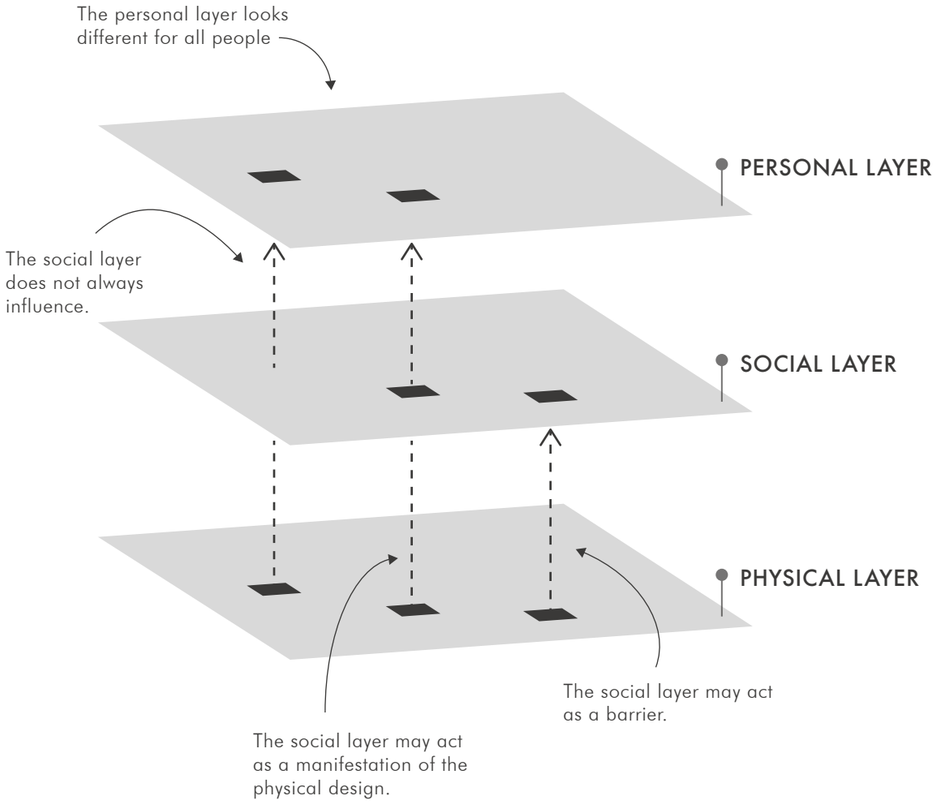


Figure 4.11 *A three layered model showing the aspects that influence visitors' attraction to an exhibit.*

Personal layer

The personal layer may be explained as the visitor's personality and interest or, as mentioned earlier, the layer that filters incoming stimuli from the social and physical layers. Based on the visitors' responses, it consists of two categories: *Learning opportunities* and P*ersonal connection*. *Learning opportunities* may be described as a combination of the visitors' prior knowledge and their interest to learn new things. *Personal connection* may be described as the visitor's own personal interests or concern for other visitors of their own group. The personal layer also includes factors such as a predetermined plan of which exhibits to look at. The personal layer is obviously different between individuals and it changes over time as the individual learns new things. Therefore, the social and physical layers will have different effects on different people and at different times.

Social layer

The social layer may be described as stimuli generated by social influences. Based on the visitors' responses the social layer consists of two categories: *Behavior* and *Situation*. *Behavior* means that the visitors' actions are directed by someone else's actions or choices, e.g. visitors getting inspired by seeing other visitors doing activities or following their parents, children or friends. *Situation* means that the current social environment affects the visitor's ability to approach the exhibit. Sometimes, the social interactions act as a manifestation of the physical design (i.e. the physical design includes those who are interacting with it). For example, a visitor might need to see other visitors interact with an exhibit in order to understand that an exhibit is a game. At other times, the social layer may act as a barrier, e.g. when a visitor is not able to approach an exhibit because it is occupied. Another example of when the social layer act as a barrier is when visitors do not notice the physical design of an exhibit because there are too many impressions from other visitors in the exhibition space that catch their attention (e.g. screams, movements, actions of other group members, etc.).

Physical layer

The physical layer may be described as the stimuli created by the physical design of an exhibit. Based on the visitors' responses, the physical layer consists of two categories: *Specific design element* and *Appearance of activity*. *Specific design element* includes a number of elements that trigger visitors' attention, such as color, lighting, sound or association (i.e. the physical design associated with a certain theme or subject).

Appearance of activity includes things in the physical design that show how the activity is performed or what you get from doing the activity. In the category Appearance of activity the most common attractiveness factors mentioned were interactive exhibits and exhibits designed as games. The visitors also highlighted exhibits shaped as rooms as attractive, making it possible to conduct the activity in privacy. The physical factors may be more or less personally connected. The design element *color* (meaning that the exhibit has an eye-catching color) will probably trigger most visitors in similar ways. On the other hand, the design element *association* (meaning that the exhibit is associated with a certain theme) probably triggers some visitors more than others, depending on the visitors prior knowledge, personal interests etc.

4.3.3 Analysis: the object level

A common response from the visitors was that it was stimuli that generated certain feelings such as happiness or excitement that made them approach the exhibit. Generating a sense of happiness among the visitors was an important aspect also for the designers.

Many of the visitors' responses to what inspired them to approach the exhibits also had to do with the physical design of the exhibit. Both the design elements and the appearance of the activity at the exhibit were highlighted. The most common aspects mentioned were exhibits that were interactive or designed as games. The designers have worked a lot with physical shapes that associate with themes that the visitors were thought to be interested in or that relate to the mathematical topic at the exhibit. The survey responses show that visitors are attracted when they see shapes that make them associate with their personal interests. However, very few visitors mentioned mathematical associations of an exhibit shape as the attracting factor.

Local consistency was something that the designers mentioned as important in order to guide the visitors through all impressions. However, this was not mentioned by the visitors. Probably because most visitors do not reflect on the uniformity of the graphic presentation. Possibly, there are also situations when the desire to attract visitors through a lot of stimuli competes with the desire for local consistency in the space.

Social influences also affect visitors' attraction to an exhibit, this is something both the designers and the visitors mentioned. The social influences may clearly both inspire and act as a barrier for the visitors.

4.4 ANALYSIS: THE STRUCTURAL & OBJECT LEVEL

During the empirical observations of the structural level of the exhibition (visitors passing, watching and interacting with the exhibits) some different types of behavioral patterns were identified. The field observations indicated that the placement of an exhibit in itself, has an important impact on the number of people watching and interacting with it. A segregated area is reached by fewer visitors, which in many cases means few visitors watching and interacting with the exhibits located there. For example, the exhibits "Voronoi" and "Jag som Fraktal" placed in the segregated gathering area had few visitors passing and also few visitors watching and interacting.

Importantly, the results also show that a large number of visitors passing an exhibit does not automatically lead to a large number of visitors watching and/or interacting with it. For example the exhibits "Sant eller Falskt 1", "Sant eller Falskt 2", "Statistiskt korrekt" and "Uppskatta världen" all had few visitors watching and even fewer interacting with it, despite being placed in the entrance of the exhibition where most visitors passed. A possible reason why few people watched and interacted with these three exhibits might be that the adjacent and popular exhibits "Räkna med AI" (that had strong visual stimuli) and "Matematikskrik" (that had strong auditory stimuli) stole all the attention. To clarify, this is an example of how the structural level and object level interact. Competition between exhibits appears both because the exhibits are placed near each other (structural level) and because the attractiveness in the exhibit designs varies (object level).

The observations also showed that a large number of visitors both passing and watching (i.e. the start of a potential interaction) an exhibit does not necessarily lead to a large number of visitors actually interacting with it. An example of a centrally situated exhibit that many visitors watched but few visitors interacted with is "Finder". A possible reason why "Finder" had comparably few visitors interacting might be that it was unclear that it was an exhibit. In the same construction as the exhibit, there was a large and conspicuous information sign describing the different areas of the exhibition. This is an example of how the design of the exhibit may act as a barrier against visitors' interactions.

Moreover, the observations also indicated that exhibits placed in segregated areas could have a large number of visitors both watching and interacting. An example of an exhibit situated in a segregated area, with relatively few people passing but a comparably large number of

people interacting was “Sifferjakten” placed along the window (on the right side of the floor plan drawing). A possible explanation for its large number of interactions may be that no other exhibits are competing for attention there. On the other hand, “Voronoi ” and “Jag som Fraktal” were also placed in a segregated area with few other exhibits competing for attraction, but they got relatively few visitors interacting. A possible reason for this difference may be that “Sifferjakten” is a more interactive exhibit than “Jag som Fraktal” and “Voronoi” with a lot of buttons to press. This is an example of how the object level may affect the number of interactions. How the exhibit is designed and what you do at the exhibit are clearly important factors for visitor attraction. Not least, interactivity has been proven a strong attraction factor according to the questionnaire responses (see *Table 4.1*).

5. DISCUSSION

5.1 USER CHARACTERISTICS

The results show that the target group of the exhibition (visitors in the ages 13-18 years) was underrepresented. Therefore, the observations and visitors' responses in this study may not reflect the group the exhibition was primarily designed for and that it aims to attract.

5.2 ACCURACY OF MOVEMENT PREDICTION

The analysis of the structural level showed that some movement patterns found in the empirical observations corresponded relatively well to those predicted by the Space Syntax analysis. They both supported a division of *zones by activity* in the exhibition space (designers' intention). The corners of the rooms were reached by few visitors making it suitable for longer lasting activities while the central parts of the exhibition space were more active.

This type of zone division is quite common in offices and schools and it's called activity based (learning) environments (SKR, 2014). In the same way as schools and offices need areas suitable for different activities it is reasonable to consider the same for a science center filled with a variety of activities. However, the zones in a science center may not be entirely the same as those in schools or offices. For example, it is perhaps unreasonable to expect quiet areas that provide conditions for activities demanding full concentration, which are often part of activity based offices and schools.

The risk with this type of zone division supported by the architectural shape of the room is that visitors may miss some areas of the exhibition that are not easily visible from the entrance (at least during their first visit). According to the Space Syntax theory there is a correlation between visibility and pedestrian flows (see *section 4.1* in the theory). Therefore, if the designers want a high flow of visitors in segregated areas of the exhibition space, additional complement that guides the visitors may be needed (e.g. a sign).

The analysis also shows that some of the movement patterns were difficult to predict. The intention to create a dynamic movement flow was supported by Space Syntax but not by the empirical observations. The empirical observations indicated a different movement pattern, where most visitors walked along a narrow area in the center of the exhibition

space. A possible explanation to the differences in our findings may be that not only the architectural design (structural level) but also the exhibit design (object level) affect movement flow (which will be discussed later). Consequently, it is not possible to use Space Syntax alone as a way to evaluate the design but it may be used as a complementary evaluation tool of a planned exhibition design.

5.3 ATTRACTIVENESS, ATTENTION & MOTIVATION

To understand the visitors' responses regarding why they approached the exhibits, a model was proposed containing three layers: personal, social and physical. The personal layer was described as the layer that filters the input and directs the visitor's behavior, while the social and the physical layers were seen as the external stimuli that affect the personal layer.

In order to better understand these three layers and how they relate to each other, theories describing the mechanism behind attention and motivation were used as explanatory models. *Selective attention* is a theory referring to the process of directing our focus to particular stimuli, while ignoring the rest of the environment (Driver, 2001). According to the theory, the attention process consists of two mechanisms: *bottom up attention* and *top down attention*. Bottom up attention is initiated by external stimuli such as salience, which refers to the perceptual quality that captures an observer's attention towards a specific object, e.g. visual effects or sound. Objects with high salience are those that stand out in relation to the objects in its surrounding. On the contrary, *top down attention* is initiated by motivation. There are two types of motivation, *intrinsic* and *extrinsic* (Ryan and Deci, 2000). Intrinsic motivation means that the motivation is based on the visitor's own interests and will to do something. However, visitors may also approach an exhibit based on extrinsic motivations, meaning that the motivation comes from external factors such as a reward or a risk of a negative outcome.

When looking at the three layer model, the personal layer consists of the visitor's motivation to approach and interact with the exhibits and the social and physical layers consist of stimuli that affect the visitors' attention and interest to approach an exhibit. Both the social and physical layers may trigger the visitor's bottom-up attention, e.g. attention may be initiated by a digital sound from an exhibit (physical layer) or a sound from a person doing an activity at an exhibit (social layer). The physical layer may also affect visitors' intrinsic or extrinsic motivations to approach

an exhibit. Visitors may pay attention to an exhibit because it reminds them of their personal interest (intrinsic motivation), or they may choose to approach an exhibit because it is designed as a game possible to win (extrinsic motivation). The social layer may also affect both intrinsic and extrinsic motivation, e.g. visitors may get interested in an exhibit because it looks fun when someone performs the exhibit activity (intrinsic motivation) or because of social pressure (extrinsic motivation).

Despite the fact that most of the attractiveness factors identified may be explained by either salience (e.g. effective visual/auditory stimuli) or motivation (intrinsic or extrinsic), there are also some factors that have nothing to do with attention or motivation. An example of this is the social category *availability* (meaning that the visitors' choice to approach an exhibit or not was based on whether the exhibits was occupied or not). If an exhibit is occupied it does not matter how attracted a visitor is to approach it.

Notably, attention is a highly subconscious mechanism which makes it hard for the visitors to tell what actually made them approach the exhibits. Therefore, it is not surprising that many of the visitors' responses were vague, describing the feelings they got (happiness, excitement, interest and curiosity), rather than the specific stimuli that generated the feelings.

Interestingly, and in accordance with our findings, the Contextual Model of Learning (Falk and Dierking, 2004) explains learning in a museum or science center as influenced by the same three categories; personal, social and physical. The main message of the previous theory is that it is not enough to look at the personal context (e.g. personal interest, previous knowledge and beliefs) in a self-directed learning process. The social and physical context will also influence the individual's ability to learn. In the model, the social context points out the importance of socio-cultural relations such as interactions and collaboration with other visitors as well as effects of seeing other visitors. The physical context on the other hand identifies the importance of the design of the physical environment, for example the ability to orient in a space. In the theory Falk and Dierking (2004) point out that the personal, social, and physical aspects are influential factors once a learning process has started. In this study we add to previous knowledge, revealing that these three aspects are crucial already during the initiation of a learning process.

5.4 DESIGN PERSPECTIVE

It is clear that the structural and object level both support and compete with each other in different ways. On one hand, the design at a structural level may influence the number of interactions at an exhibit. On the other hand, stimuli from nearby exhibits (object level) may act as stimuli or barrier against predicted movements based on the structural level. Furthermore, different objects (exhibits) may also compete for the visitors' attention, which has also been shown in previous studies (Bitgood, 1992, 2010; Melton, 1972). Accordingly, when designing an exhibition, placement of an exhibit is of great importance and should be taken into account.

Physical placement may be "compensated" with other stimuli attracting a visitor. It is also important to consider potential competition between the individual exhibits and between the structural and object level. Again, individual design of an exhibit could diminish competition. Apparently, internal confusion in the exhibit design may also affect exhibit attractiveness, e.g. the exhibit "Finder" (mentioned in the analysis in *chapter 4.4*), that was a combination of a sign and an exhibit. To summarize, there are three physical design aspects identified that may trigger or act as barriers for the visitors' attraction to the exhibits:

1. The attractiveness of the exhibit itself including exhibit style and activity (object level)
2. Internal confusion regarding what to do at the exhibit (object level)
3. Competition from exhibits nearby, e.g. other exhibits stealing attention because they are located nearby and have stronger stimuli (structural level and object level).

Based on the analyses of both the structural and the object level of the exhibition space, it appears that some parts of the physical design will affect visitors in a similar way, e.g. how they move in a room (depending on its visibility) and how they react to stimuli related to salience (colors, sounds etc.). Other parts of the physical design may trigger visitors in different ways, depending on personal interests, prior knowledge etc. It is difficult to create an exhibition with a physical design that triggers visitors' motivation to approach an exhibit and it requires the designers to have a deep knowledge about the target group.

One way to do that is obviously to interview the people that belong to the target group in advance or to search for statistics explaining the characteristics of the target group. Of note, there may also be a risk in designing an exhibition aimed to attract solely a specific target group since it may exclude groups who do not belong to the target group. In

general, the *Mathrix* exhibition seemed to be appreciated by visitors in other ages than the pre-specified target age which may reflect that the designers did not focus too much on a specific age group. In this case, with a mixed group of visitors, this is probably a key to success. However, the exhibit "Finder" (where the visitors can search for their soulmate through mathematics set theory) was based on information from visitors in ages 13-18 years. Therefore, many of the visitors who passed this exhibit were not able to conduct the activity properly.

The social influences vary depending on how crowded an exhibition is. When there are a lot of visitors at an exhibition there will be more social influences than when the exhibition is empty. As shown in the results, social influences may both disturb and support visitors attention to exhibits. However, it is difficult to know in advance how it will affect the visitors in the exhibition. One possible way to approach this issue is to create scenarios that may occur, e.g., what will happen when the exhibition is empty and when the exhibition is crowded. This is of course very difficult to predict and previous knowledge and experiences should be sought. Careful evaluation of a finished exhibition is obviously also an important way to gain information to improve future exhibitions. Inspiration may also be obtained from the field of interaction design where the method of *use scenarios* are often applied, which describe potential paths users might take when interacting with a system (Alexander and Maiden, 2005).

The findings in this study describe the complex structures attracting visitors to certain exhibits. Even so it may be helpful for the designer of an exhibition to have these structures in mind, in order to attract as many individuals as possible.

5.5 LIMITATIONS

The order of the data production was important for this study to ensure minimal intrusion on the observations. In retrospect, it might have been easier to conduct a comprehensive evaluation of the space after the information of the designers' intentions was obtained. That would have made it possible to direct the observations and questionnaire to the design intentions. However, the purpose of this study was not primarily to conduct a comprehensive evaluation of the exhibition, but to inductively find behaviors and patterns among the visitors and see how they relate to the designers' intentions and existing theories.

An obvious improvement of the observations conducted would have been to use thermal cameras for more precise and comparable results of the observed movement. Another way to get more precise observations would have been to use ordinary cameras to record the movement patterns in the room. However, there were several reasons not to use video recordings. For example, it would have increased the risk of intruding on visitors and it would have been hard to find a camera position that gave an overview of several exhibits at a time.

As shown in the results, the target group of the exhibition was underrepresented. The reason might be that teenagers simply do not find their way to Universeum, especially not during school holidays, which was when the study was conducted. If the data construction would have taken place on a normal week instead, the age distribution of the visitors would probably have looked different since high school classes often visit Universeum for educational purposes. However, in such a situation, the visits would not have been voluntary and the aim of the study was to include only voluntary visitors. On the other hand, since science centers have an educational focus it might be important to study groups that are visiting as a part of their education as well.

Most exhibitions include physical designs that link the structural level (layout) and the object level (exhibits), e.g. through signs that guide the visitors through the exhibition space. This type of physical design was not examined in this study.

5.6 FUTURE RESEARCH

This study may be seen as an idea base for future studies of architectural design in science centers. There are several hypotheses presented that would be interesting to test on other empirical cases for further validation.

One possible future work would be to ask visitors in other science centers what made them approach different exhibits (in the same manner as in this study) in order to test the usability of the three layered model in other settings than the empirical case used in this study.

Another interesting future work would be to study and compare science center exhibitions in different situations (e.g. during different times of the day) in order to formulate possible use scenarios. That would strengthen the usability of the three layered model.

6. CONCLUSION

This study showed that movements in an exhibition may be partially predicted. The designers' intentions to create zones by activity was actually supported by both the theoretical spatial analysis (Space Syntax) and the empirical observations. However, the results also showed that the design of the exhibits has a significant impact on the final movement pattern at an exhibition.

Furthermore, this study showed a considerable difference in the proportion of visitors interacting at the different exhibits, from less than 30% up until around 70%. There was also a significant difference between exhibits in the proportion of visitors with potential interaction (i.e. visitors watching the exhibits) and actual interaction. The differences may be partly explained by the design intention to create exhibits with different types of activities and engagement from the visitors. However, the observed differences may also be explained by several aspects in the physical design at both a structural and an object level: 1) The attractiveness of the exhibit itself including exhibit style and activity (object level), 2) Internal confusion e.g. regarding what to do at the exhibit (object level) and 3) Competition from exhibits nearby, e.g. other exhibits stealing attention because they are located nearby and have stronger stimuli (structural level and object level). In addition to the physical aspects there are also personal and social aspects affecting exhibit attractiveness (shown in the questionnaire responses). The personal, social and physical aspects and how they relate are described in a three layered model.

Moreover, this study shows that you could not rely solely on theory-based analysis when examining architectural designs. Visitors´ decisions to attend an exhibit are influenced by exhibition design at a structural level but also by several factors related to personal, social and physical aspects. These aspects may be more or less conscious. The three layered model formulated in this study (based on the empirical case and motivated by existing theories) may be a helpful tool both in order to understand these three aspects. It may be used both for evaluation of existing designs but also as a design tool during a creative process. By combining theoretical prediction models with the three layered model, exhibition designers get an understanding of visitors movements and behaviors based on both visibility and attractiveness.

Furthermore, exhibition design is a complex process, with difficulties to predict attraction to specific exhibits. This study presents a possible

approach to use for future evaluations of exhibitions and other architectural designs, based on two empirical perspectives: design and use, that are both compared with existing theories and prediction models. By analyzing data from both the users and the designers, a deeper understanding of the correlation between visitors behaviors and the spatial design is obtained.

These findings may help exhibition designers to improve the overall interaction rate at an exhibition and the attractiveness of exhibits.

REFERENCES

Alexander, I. F., & Maiden, N. (Eds.). (2005). Scenarios, stories, use cases: through the systems development life-cycle. John Wiley & Sons.

Allen, S. (2004). Designs for learning: Studying science museum exhibits that do more than entertain. Science education, 88(S1), S17-33. https://doi.org/10.1002/sce.20016

Benedikt, M. L. (1979). To take hold of space: isovists and isovist fields. Environment and Planning B: Planning and design, 6(1), 47-65. https://doi.org/10.1068/b060047

Bobbe, T., & Fischer, R. (2022). How to design tangible learning experiences: A literature review about science exhibit design. DRS2022: Bilbao, 25.

Braun, V., & Clark, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Bitgood, S. (1992). The anatomy of an exhibit. Visitor Behavior, 7(4), 4-15.

Bitgood, S. (2010). An attention-value model of museum visitors. Center for Advancement of Informal Science Education: Washington, DC, USA.

Callanan, M., Cervantes, C., & Loomis, M. (2011). Informal learning. Wiley Interdisciplinary Reviews: Cognitive Science, 2(6), 646-655. https://doi.org/10.1002/wcs.143

Coe, J. C. (1985). Design and perception: Making the zoo experience real. Zoo Biology, 4(2), 197-208. https://doi.org/10.1002/zoo.1430040211

Driver, J. (2001). A selective review of selective attention research from the past century. British journal of psychology, 92(1), 53-78.

Esaiasson, P., Gilljam, M., Oscarsson, H., & Wängnerud, L. (2007). Metodpraktikan. Konsten att studera samhälle, individ och marknad, 3(1), 12-19.

Etikprovningsmyndigheten. (2003). What the Act says.https://etikprovningsmyndigheten.se/en/what-the-act-says/

Falk, J. H., & Dierking, L. D. (2004). The contextual model of learning. Reinventing the museum: Historical and contemporary perspectives on the paradigm shift, 139-142.

Hillier, B., & Hanson, J. (1989). The social logic of space. Cambridge university press.

Hillier, B., & Tzortzi, K. (2006). Space syntax: the language of museum space. A companion to museum studies, 282-301.

Hillier, B. (2007) Space Is the Machine: A Configurational Theory of Architecture. Space Syntax, Electronic Edition, London.

Katsuki, F., & Constantinidis, C. (2014). Bottom-up and top-down attention: different processes and overlapping neural systems. The Neuroscientist, 20(5), 509-521.

Macià, M., & García, I. (2016). Informal online communities and networks as a source of teacher professional development: A review. Teaching and teacher education, 55, 291-307.

Melton, A. W. (1972). Visitor Behavior in Museums: Some Early Research in Environmental Design. Human Factors, 14(5), 393–403. https://doi.org/10.1177/001872087201400503

Oktay, J. S. (2012). Grounded theory. Oxford University Press.

Peart, B. (1984). Impact of exhibit type on knowledge gain, attitude change and behavior. Curator, 27(2): 220- 237. https://doi.org/10.1111/j.2151-6952.1984.tb01278.x

Penn, A., & Turner, A. (2002). Space syntax based agent simulation. Springer-Verlag.

Rogoff, B., Callanan, M., Gutiérrez, K. D., & Erickson, F. (2016). The Organization of informal learning. Review of Research in Education, 40(1), 356-401. https://doi.org/10.3102/0091732X16680994

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary educational psychology, 25(1), 54-67. https://doi.org/10.1006/ceps.1999.1020

Stocker, M. (1995) Exhibit sound design, Museum International, 47:1, 25-28, https://doi.org/10.1111/j.1468-0033.1995.tb01219.x

Sveriges Kommuner och Landsting. (2014). Aktivitetsbaserade arbetsplatser I Offentlig sektor. https://skr.se/download/18.550f5b1717d613c-03137c7b3/1639148163003/7585-208-9.pdf

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. American journal of evaluation, 27(2), 237-246. https://doi.org/10.1177/10982140052837

Turner, A. (2001). Depthmap: a program to perform visibility graph analysis. In Proceedings of the 3rd international symposium on space syntax (Vol. 31, pp. 31-12).

Turner, A., Doxa, M., O'sullivan, D., & Penn, A. (2001). From isovists to visibility graphs: a methodology for the analysis of architectural space. Environment and Planning B: Planning and design, 28(1), 103-121. https://doi.org/10.1068/b2684

Turner, A. (2004), DepthMap4: A Researcher's Handbook, UCL. http://www.vr.ucl.ac.uk/depthmap/depthmap4.pdf

Universeum. (2022). I nya Mathrix finns matematiken överallt. https://www.universeum.se/nyheter/i-nya-mathrix-finns-matematiken-overallt/

Walker, D., & Myrick, F. (2006). Grounded theory: An exploration of process and procedure. Qualitative health research, 16(4), 547-559. https://doi.org/10.1177/1049732305285972

Webb, E. J., Campbell, D. T., Schwartz, R. D., & Sechrest, L. (1999). Unobtrusive measures (Vol. 2). Sage Publications.

Yin, R. K. (1984). Case study research.

A. ROOM DIVISION DURING THE OBSERVATIONS

During the observation of frequency of behavior, the exhibition space was divided into nine sections, containing 1-3 exhibits each.

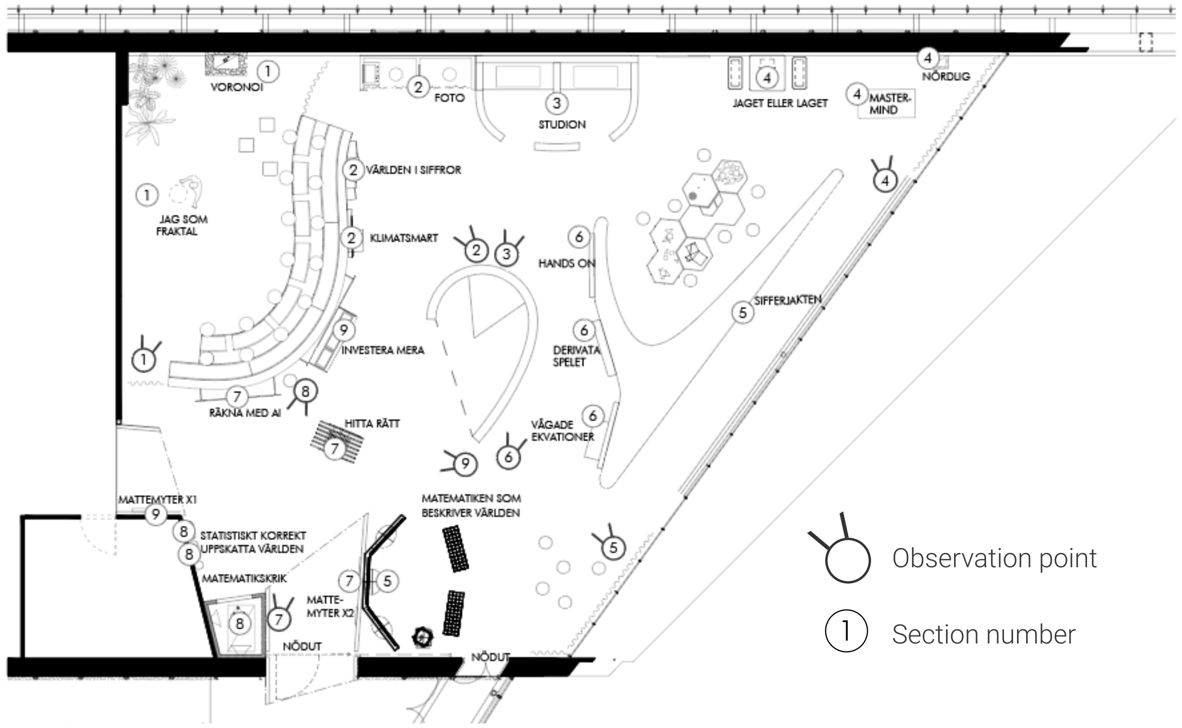


Figure A.1 *Room division during the observations*

APPENDICES

B. PROTOCOL FOR OBSERVATIONS (FREQUENCY)

Mathrix: Observation Frequency

Section: ______ Date: ____________ Time of day: _________

Duration: _________ Total nr visitors: _______

Name of exhibit		Name of exhibit		Name of exhibit	
Pass by	Look at	Pass by	Look at	Pass by	Look at

| One visitor in target group ┼ One visitor interacting |⁺ One visitor above target group ||ₒ

||| Three visitors in target group ╫ Two visitors interacting |||₋ Three visitors below target group Two visitors very different ages

Figure A.2 *Protocol for observations*

C. QUESTIONNAIRE

1. The exhibit used*

a. FOTO

b. Studion

c. Jaget eller Laget

d. Räkna med AI

e. Matematikskrik

2. Age (mark the ages of the people in your group)*

◯ Younger than 13-years old

◯ 13-18-years old

◯ Older than 18-years old

3. Please describe your group (number of people, how you are related).

_____

_____

4. What made you choose to approach this exhibit?

_____

D. INTERVIEW GUIDE

The interview was divided into three sections

1. The architects/art directors role
2. The design of the general structure
3. The design on a detailed level

---

1. The architects role (approximately 5 min)

Q: What has been your role when it comes to the design of Mathrix?

2. The design of the general structure (approximately 20 min)

Q: Tell us about the layout and design in general.

Intention with the Q: design in general, zones in the room, placements of exhibits and seats etc, shapes, different activities in different areas, how the exhibits are grouped etc.) - any thoughts other than content?, different ways to capture attention/interest, different stands different importance? were some stands in need of more "decor" to become interesting (due to less interesting content?), specifically around the design linked to the target group 13-18 years etc., catching attention)

3. The design on a detailed level (approximately 25 min)

Q: Tell us a bit more about the exhibit. What was important for you when you designed it at what do you think will attract visitors to the exhibit?

Intention with the Q: How/If they worked on capturing attention and if its done differently at different exhibits.

Extra:

- *How have you planned to make the exhibition/exhibits attractive to the target group? Would you have done thing differently for another group?*
- *Have you thought of different ways to make the visitors attracted to different exhibits?*
- *What feeling did you want the visitors to get by visiting the exhibition and the different exhibits?*

E. QUESTIONNAIRE RESPONSES

Table A.1 *Original version of questionnaire responses presented in subsection 4.3.1.*

	Learning opportunities	Personal connection
PERSONAL	***Learning goals*** *"Bilder, lära sig ta bra bilder ", "Intressant med AI" och "ny teknik"* ***Knowledge level*** *"Father is mathematician" , "Vi har studerat musik"*	***Personal interest*** *"Intresset för musik" , "Jag gillar att fotografera"* ***Concern for others*** *"Tänkte det passade en 5-åring"* *"Vi är här med barnen, försöker få dem intresserade"* ***Predetermined plan*** *"Var den som var näst", "Kollar vad de flesta är"*

	Behavior	Situation
SOCIAL	***Sense of belonging (external)*** *"Såg någon annan göra den innan"* *"Det var några som provade den innan"* ***Sense of belonging (internal)*** *"Följde mina barn", "Barnet styr"*	***Availability*** *"Den var ledig", "Den var tom"*

	Specific design element	Apperance of activity
PHYSICAL	***Color*** *"fin färg", "röda mikrofonerna", "Lockande med färger"* ***Moving visualization*** *"Visualiseringen", "såg visualiseringen"* ***Light*** *"Ljuset var intressant", "Ljuset"* ***Name*** *"Namnet lät spännande", "Matematikskrik lät kul"* ***Sound*** *"Hörde andra skrika" , "it made noise"* ***Association*** *"Vi trodde man tog kort", "Det såg spännande ut med ett piano"*	***Outcome/results*** *"Intressant att se hur den mäter åldern och reaktioner", "Man blev en figur"* ***Interactivity*** *"Trycka på knappar", "För det fanns knappar som var inbjudande"* ***Gamification*** *"För att det var ett spel", "Utmaning", "Gillar tävla"* ***Spatial privacy*** *"Pappan såg ett rum och tyckte det såg spännande ut att man kunde gå in", "Det fanns en gardin som gömde attraktionen vilket intresserade oss mer att undersöka"*

GENERAL	***Spontaneity/Curiosity*** *"Spontanitet", "Blev nyfiken", Testa något nytt"* ***Excitement "****Såg spännande ut",* ***Fun*** *"It looked like it was fun", "It looked fun"* ***Interesting*** *"Looked interesting", "seemed interesting"*

F. INTERVIEW TRANSCRIPTS (STRUCTURAL LEVEL)

Table A.2 contains a selection of quotes (in English and Swedish) describing the designers' intentions of the structural level of the exhibition space (described in subsection 4.2.1).

Table A.2 *Selection of interview transcripts (structural level).*

English	Swedish
Zones by activity	
" ... the further you reach into the exhibition space the calmer it should get, both in the gathering area and by the puzzle corner. You should be able to stay there for longer periods" *"... here, we planned a puzzle corner or a place where you could stay for a longer period of time, and maybe sit down."* *"...to play or perhaps do things together. I said play, but some things may also be a game that captivates people."* *(Points at the walls two walls were "Derivata" and "Klimatssmart" are located) "... the idea was that you should be able to move along the wall and perhaps not take too long. But of course there is a risk that you just move past it..."*	*"... ju längre in man kommer i utställningen, både där vid samlings-ytan och där vid pusselbordet att det skulle vara lugnare och att man kunde befinna sig där lite längre..."* *"... här tänkte vi att det skulle vara en pusselhörna eller en plats där man kunde stanna lite längre tid och kanske sitta ner..."* *"... också att man spelar, eller kanske gör saker tillsammans. Nu sa jag spela, men att vissa saker kanske också är ett spel som håller fast folk."(* *(Pekar på montrarna längs väggarna där bl.a. "Derivata" och "klimatsmart" är placerade) "... tanken att man ska kunna röra sig längs den här väggen och kanske inte ta så lång tid på sig. Men det finns såklart risk att man bara rör sig förbi det..."*
Dynamic flow to maintain a joy to discover	
"It's a bit like a labyrinth, which was also the idea. Not like a scary labyrinth, but a labyrinth where there's something behind every corner." *"...what we found exciting about this winding plan is that it becomes more dynamic so that you don't see everything at once and you have to move around to discover new things and signs and such. It was a pretty convenient plan to work with in terms of creating an interesting movement pattern and flow."*	*"Det är ju lite som en labyrint, som också var tanken. Inte som en labyrint som att det ska vara läskigt, utan labyrint som att det finns någonting bakom varje hörn."* *"... det vi tyckte var spännande med den här svängande planen är att den gör det mer dynamiskt - du inte ser allt på en gång och du måste gå runt i rummet för att upptäcka nya saker och skyltar och så. Det var en ganska tacksam plan att arbete med utifrån att skapa ett intressant rörelsemönster och flöde och så."*

G. INTERVIEW TRANSCRIPTS (OBJECT LEVEL)

Table A.3 and Table A.4 contains a selection of quotes (in English and Swedish) describing the designers' intentions of the object level of the exhibition space (described in subsection 4.3.1).

Table A.3 *Selection of interview transcripts (object level)*

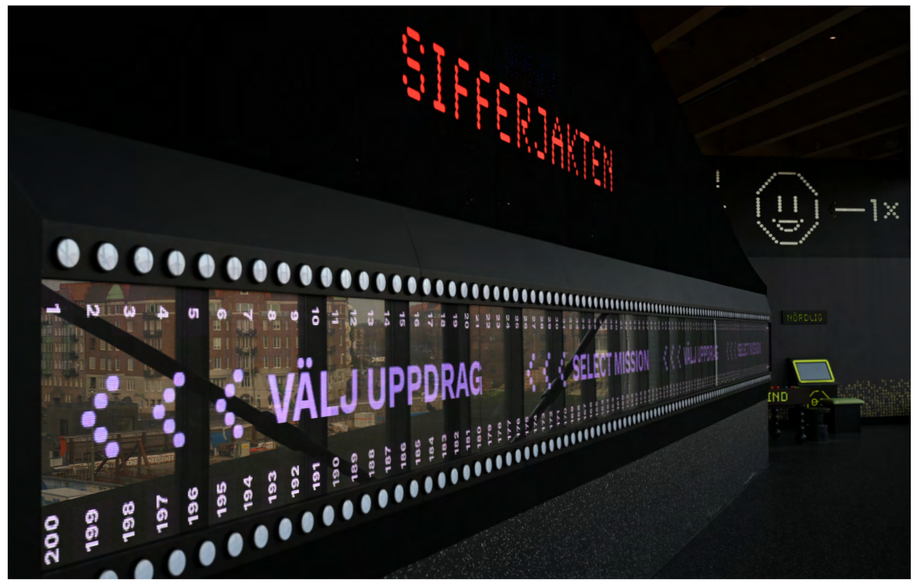
English	Swedish
Global associations or more expressive elements	
"We have tried to be clear in our communication at the exhibits, bars as bar charts, the curve for "Derivata" and the hands at "Hands on" " *" "Världen i siffror" is based on gapminder, therefore we have used Hans Roslings bars"* *"...the smiley figure is easy to work with".* *"Sometimes, we may need to be more expressive in order to catch peoples' attention and at other times we don't need to be as expressive because there are already so many things aiming for visitors' attention.* *It is a balance."* *"This one ("Studion") is not as expressive as many other exhibits are. But then we thought, here the topic may speak for itself."*	*"Jag kan också säga det här med montrarna, där har vi försökt vara tydliga. Där har vi staplar som stapeldiagram, och "Derivata" har ju kurvan, "Hands on" har händer"* *"Den här "Världen i siffror" bygger ju på gapminder och då har vi tagit roslings staplar"* *"...smiley som figur är tacksam att jobba med..."* *"Ibland kanske vi behöver dra på mer för att skapa uppmärksamhet och ibland kanske vi inte behöver göra så mycket för att det redan är så mycket som drar. Det är en balans."* *"Den här (Studion) är ju inte så expressiv som många andra är. Men då tänkte vi att här kan ämnet tala för sig själv"*
Appearance of activity	
Outcome/results *"I don't know if the visitors understand it, but the sounds is visualized as a sound wave in the ceiling"* ***Interactivity*** *"I think that many people are keen doing more interactive things like moving a joystick"* *"Buttons are fun to press"* ***Spatial privacy*** *"I think it is fun that you are able to walk into something, rather than standing along the wall in the exhibition. I think the fact that the exhibit is shaped as a room is what attracts visitors."* *"You enter the photo booth and do your own thing".*	***Outcome/results*** *"... nu ser man det som en ljudvåg (skriket i "Matematikskrik"). Jag vet inte om man uppfattar det dock..."* ***Interactivity*** *"Jag tror man gillar spakar och det här analoga", "Knappar är kul att trycka på"* ***Spatial privacy*** *"Att man kan gå in i någonting tycker jag är roligt också, att man inte bara står längs med en vägg eller så utan det blir ett eget rum, det tror jag är det attraktiva i den"* *"Man går in i det här fotobåset och så får man göra sin grej"*

Table A.4 *Selection of interview transcripts (object level)*

English	Swedish
Local consistency	
"Even though all the exhibits look different, you should still feel a little safe and know when there is information you should read and take in... so it doesn't become too much information to take in. Because there is a lot going on in here"	*"Även fast det ser olika ut på alla montrar så ska man ändå känna sig lite trygg och veta när det är information man ska läsa och ta till sig... så att det inte blir för mycket. För det händer ju väldigt mycket här"*
Reflections on social interactions	
"But maybe you have to see someone scream before you go in there, otherwise it might be hard to understand what it is..." *"... then it's also very interesting... how it may affect you to be able to go into an exhibit and not be seen. Especially here in this path in the middle. Maybe it is a bit scary to try and make mistakes.... then it's easy to get finished faster. Or, I can imagine that some people.... who think math is difficult give up quickly. Whereas once you have a booth to sit in you can probably sit there for a little while."*	*Men man kanske måste se någon skrika innan man själv går in där, för att man inte riktigt fattar vad det är..."* *"... sen är det väldigt intressant ... vad gör det att man kan stänga in sig i en monter och inte är sedd. Särskilt dem här som är lite som i ett stråk här i mitten. Det kan kanske vara lite läskigt att testa och göra fel... då är det lätt att vara lite snabbare. Eller jag kan tänka mig att vissa...som är lite osäkra på matte bara, ah jag fatta inte och så ger man upp. Medan när man väl har tagit ett bås så kan man sitta här ett litet tag eventuellt."*

H. PHOTOGRAPHS OF THE EXHIBITION SPACE

Figure A.3 *Top image: view from entrance 2. Lower left image: the exhibit "Matematikskrik". Lower right image: the exhibit "Studion".*



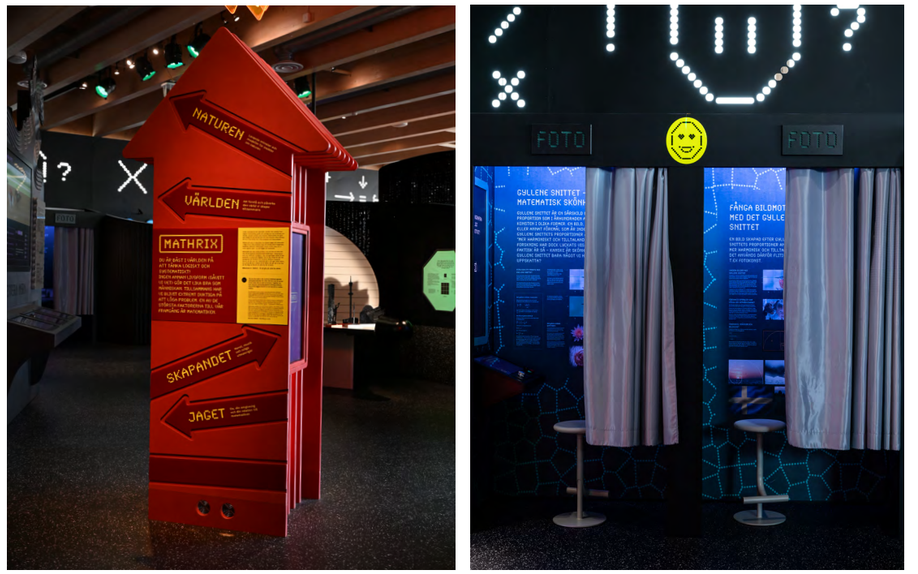


Figure A.4 *Top image: the exhibit "Sifferjakten". Lower left image: the exhibit "Finder". Lower right image: the exhibit "Foto".*

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