Organized Chaos!

Untangling multigenerational group interactions in a gamified science center

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**Sammanfattning**

Denna induktiva studie undersöker samspelet inom besöksgrupper under ett science center besök. Genom att använda förenklade interaktions analyser av inspelade videor; utforskar jag gruppdynamik när det gäller att avgöra vem tar ledningen samtidigt som deltagarna interagerar med olika typer av experiment. Från observationer, föreslår jag att en ålder av olika gruppmedlemmarna och vissa specifika designaspekter i experimenten spelar bland den viktigaste rollen i fastställandet av ledarskap. Tonåringar i en grupp tenderar att ta ledningen och dominera under en interaktion grupp, medan yngre barn tycker om att utforska fritt och leder gruppen från ett experiment till nästa utan att fokusera på att avsluta dem på rätt sätt. När det gäller utformningen av ett experiment krävs kognitiva färdigheter som leder till att vuxna och tonåringar tar ledningen, men om ett experiment kräver exploration tar småbarnen ledningen. Denna studie kommer att vara till nytta för forskare och interaktionsdesigners som fokuserar sitt arbete på science center eller museiutställningar.

**Abstract**

This inductive study investigates interactions within groups of visitors during a science center visit. Using simplified interaction analysis of recorded videos; I explore the group dynamics in terms of what determines who takes the lead while multigenerational groups interact with different types of experiments. From the observations, I suggest that the age of different group members and specific design aspects of the experiments play the most important roles in the emergence of leadership. Teenagers in a group tend to take the leadership and dominate during a group interaction, while young children like to explore freely leading the group from one experiment to the next without focusing on finishing them properly. As for the design aspects, if an experiment requires cognitive skills then adults and teenagers take the lead but if an experiment requires physical skills and provides immediate feedback then young children take the lead. I also suggest, instead of guiding the young children in the group, adults tend to become observers during engagements. This study will be useful for researchers and interaction designers who are focusing their work on the behavior of multigenerational groups in science center or museum settings.
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1. Introduction

There has been a recent increase in the use of interactive technology in science centers. One of the main reasons behind this use of interactivity is to engage both body and brain of the visitors during their visit. Bruner (1973) argues, physical engagement with something increases the activeness and involvement in learning, which is not possible through passive listening or watching. Effective learning takes place when experience with the world provides the meaning of engagement. Allen (2004) suggests the need of more studies of nonverbal forms of learning in science museum settings to understand the affect of interactivity, especially with children.

Due to the large-scale deployment of science centers where hundreds of experiments call for visitors’ attention, it gets really difficult for most of the visitors to create a manageable route to explore some of the experiments, have a meaningful group interaction and learn something from that engagement. By providing a focused route during visit and by encouraging close collaboration among group members, gamification of a science center aims to solve this problem and make group visit experiences more enjoyable. Science centers are constantly benefiting from increasing number of game elements implemented in their design; resulting in attracting a larger crowd. However, little is known about the amount of influence gamification has over the group dynamics of visitors at a science center.

The study conducted in this thesis is based on an ongoing project at Tom Tits Experiment. Operating since 1987, Tom Tits is a science center located south of Stockholm Sweden, which receives up to 200,000 yearly visitors. It has approximately 7000 square meters of indoors exhibition space and 8000 square meters of outdoors exhibition space. Most of its artistically designed exhibition space is filled with in-house made or modified experiments ranging over a wide range of topics from natural sciences and engineering. Waern et al. (2014) designed an overarching game "The Mission", to gamify this science center’s experiments and provide a guided route for the visitors. The objective of this gamification is to provide a lasting positive experience that is linked to scientific phenomena. The focus of this project was to attract the generation of kids growing up with computer games, to increase collaboration among families visiting the science center, and to eliminate the risk of "museum fatigue" (Falk et al. 1985). A typical group of visitors Tom Tits wants to attract is a multi-generation group that can consist of: mother, mother's new boyfriend, the mother's 4-year-old, and the mother's 8-year-old and her boyfriend's 14-year-old. The video data presented in this thesis was collected in this science center over the summer of 2014.

To describe the interaction, behavioral pattern and psychological processes taking place within a social group or among different groups, social psychologist Kurt Lewin (1944) came up with the term group dynamics. Through empirical research, this is an attempt to scientifically study the way groups and individuals act and react to changing circumstances. Group dynamics has roots in both sociology and psychology. Sociologists have long recognized that groups link individuals to society. They are more interested in group-level analysis where each individual is just a part of the group and studying the group as a whole also represents that individual's behavioral pattern. On the other hand, psychologists focus on individual members of the group through individual-level analysis. They study how people change their behavior when they are in groups rather than alone (Steiner 1974). For the thesis presented here, I am focusing on specific behavioral aspects of different groups of visitors in science centers. Specifically the aim of my observation is to find out what roles various individuals are taking in the group? Who is leading the group while they engage with different types of experiments?

In this thesis, I investigate how the members of a group work together while interacting with an experiment by empirically analyzing their behavior in the context of a gamified science center.
Specifically, it examines what determines who takes the lead while interacting with the experiments in which game elements have been applied. The overall research question that guided the research as follows –

**What determines who takes the lead while interacting with an experiment during a group engagement?**

The following sub questions need to be answered to answer the main question -

1. Who is taking the lead starting and quitting an experiment? Since the group might follow the member who is going first, or the member quitting first might drag the whole group with him or her, this is important in the emergence of leadership.

2. What are the design factors of the experiments that contribute to the emergence of a leader in the group? If an experiment is focused on cognitive skills does it affect the leadership? If it provides delayed feedback does it affect the leadership?

3. What are the aspects of the group (age, size) that contribute to the emergence of leadership?

The research design includes four hours of videotaped observations taken from a first person point of view using go-pro cameras during multigenerational group engagements in Tom Tits. This thesis will contribute to the interaction design area of human computer interaction; specifically in the design of interactive environments for multigenerational groups. Those who are working with group dynamics in science centers as well as designers of interactive exhibits will find this study of their interest.

2. Background

2.1. Gamification in science centers

Gamification is defined as taking game design elements and using those in non-game contexts (Deterding et al. 2011). To encourage collaboration among visitors and to increase the level of engagement with the exhibits in Boston Museum of Science, Klopfer et al. (2005) designed an interactive game called Mystery at the museum. The results show higher collaboration among groups and deeper parent child interactions. Csikszentmihalyi and Hermanson (1995) argue interest and curiosity are the initial triggers that make the visitors stop and interact with an exhibit. Once the visitors are fully engaged with an exhibit, they achieve a flow state, which is automatic and spontaneous as long as the activity is intrinsically motivated. This flow state provides them with a sense of discovery about themselves and surrounding environment. This flow state can be sustained by providing clear goals that can be reached through the exhibits. Gamification of a science center sets clear goals for the exhibits, which should result in higher level of interaction with the exhibits, but does it also invoke higher level of interaction within individual groups, that is yet to be explored.

2.2. Learning in science centers

Previous studies of interactions within groups of visitors in science museums and science centers focused on the physical and verbal behavior of the members of the group while they interact with different exhibits. Different learning related behavior such as pointing and talking about parts of exhibits, curiosity about exhibits, reading of labels and even gazing at exhibits have been documented in those studies (Bitgood 1993; Hilke 1987; McManus 1987; 1988; 1994). Hilke (1987) suggests multigenerational families come up with specific strategies during their visits. Among those strategies,
individuals tend to observe others in the group and learn how to interact with the exhibits, while cooperative strategies include asking each other’s for guidance. Specifically, children choose their parents as interactive partners and ask for guidance during engagements. Based on this, I expect to see adults guiding their young children during their interactions with the experiments. Among the groups of museum visitors, multigenerational families are the most common and these groups tend to make their own path and follow it while interacting with the exhibits during their visit (Diamond 1986; Falk and Dierking 1992; 2000; Falk 2006). Many researchers (Crowley and Callanan 1998; Falk and Dierking 2000; Martin 1996) agree that learning in science centers is strongly dependent on the social interactions of the group members during visit. While observing group interactions in a museum setting, Hilke and Diamond (1988) insist on paying special attention to the different roles and relationships among the members of a group. Multi-generational groups rely on individual group member’s interest while interacting with the exhibits that makes learning in science centers a social experience (Falk et al. 1998; Hilke 1985). But not all the group members actively participate in all exhibits, the question remains what determines who takes the lead in what type of experiments and whether it can be related to the design of the experiment, the size of the group or the age of different group members.

2.3. **Dynamics of multi-generation groups**

The most common groups of visitors in a science center are families that include both adults and children (Diamond 1986). From earlier research, we already know children are less thorough exploring the space of the experiments (Schauble et al. 1991) and more likely to exit the experiment without solving the experiment after a few tries (Dunbar and Klahr 1988). Unlike adults, children usually don't predict about the outcome of the experiments and many times their predictions fail to match the conclusions they draw at the end of the experiment, which suggests they often forget the purpose of the experiments as they proceed (Kuhn et al. 1995). In the case of groups with both adults and children, when the group engages with an experiment, adults are more likely to keep mental notes on their attempts and recall those notes during their next try to finish the experiment. But for children, they are likely to engage with the experiment multiple times without focusing on keeping any sorts of notes from their previous try (Schauble 1991). During collaborative engagement with an experiment at the science center, since the adults have more knowledge on the topic and better grasp at the experiment itself, it is expected that adults will assist the children in the group. Webb and Palincsar (1996) showed that in groups with mixed levels of ability, less competent members of the group benefit from interactions with the more competent members. However, in the case of scientific experiments at a science center, it is not known that parents understand the need of assisting their children when they are failing to finish an experiment properly or prematurely exiting an experiment thinking it has been finished already. Moreover, even if the parents understand this need and try to assist the children, they may not know how best to help.

Building on existing research, in this study I investigate the dynamics of multi-generation groups as they engage with different types of gamified experiments at a science center. I thoroughly observe the patterns of interaction that emerge as the adults and children in a group collaborate with each other during their engagement along their route through the exhibit area. My first objective is to find out who takes the lead when the group interacts with an experiment. Based on existing knowledge, I expect to see the children exploring the space in a chaotic way without focusing on collecting the reward points from the gamified experiments by finishing those properly. I also expect to see parents guiding their children when they are stuck with an experiment in some cases and taking the lead themselves to finish the experiment in most others.
I also try to untangle these chaotic explorations of experiments by different groups that can be observed on the video footage collected from Tom Tits science center. My second objective is to organize this chaos in a meaningful way and characterize the patterns of interaction to find out what aspects of a group’s structure contribute in the emergence of who is leading the group during their engagements. Finally, I investigate the relationship between the behaviors of different group members as they engage with different experiments and the design of the experiments, to determine what design aspects of an experiment contribute in the emergence of leadership during group engagements. Specifically I try to determine if an experiment being cognitive skills based versus physical skills based has any effect on the leadership of the group. I also look into the effect of feedback provided by an experiment during engagements.

2.4. **Immediate or delayed feedback**

Bandura (1997) describes how people's beliefs about their abilities to do certain activities and their outcome expectations can influence their behavior. He proposes the self-efficacy theory, which argues children's intention to engage in an activity can be increased by providing immediate motivating feedback and positive experience. If an experiment provides immediate feedback then children will more likely engage with it more often. If a child needs to wait sometime to get feedback from an experiment then he/she might get bored and prematurely opt out from the experiment. This encourages me to observe how design variations of different experiments contribute to the interactions among group members. I expect to see young children taking the lead to engage with an experiment where the feedback is immediate; while adults taking the lead on experiments that take longer time to finish and to get feedback.

2.5. **Influence of age**

Piaget (1952) proposed that children go through four stages of cognitive development as they mature. From their birth up to the age of 2 years, children stay in the sensori-motor stage, here they can differentiate self from other objects and achieve object permanence. Children between the ages of 2 to 7 years are in pre-operational stage. They are egocentric, they struggle with logical thinking and they are unable to follow other people's viewpoints. As a result, they are more interested in exploring freely instead of sticking with the group. The next stage is concrete operational (7-11 years) when children can think logically about objects and events but their attention span is still under development. As a result they tend to lose interest quickly and opt out from a task in the middle of an engagement. Finally, age 11 years and up is the formal operational stage. At this point most of the children can think logically and their motor coordination skills are also developed. Building on this, I expect to see significant difference in the interaction pattern within groups with two or more children. My assumption is, teenagers of the family will be more dominant during group activities, they will take the lead and guide the group during their engagements with the experiments focused on cognitive skills; while the younger children will be exploring freely from one experiment to the next stopping at the experiments that allow free play. Due to their under developed cognitive and motor skills, children below the age of 12 years will have difficulty finishing many of the experiments and will opt out prematurely. From their study on people’s activity patterns on public spaces, Brignull and Rogers (2003) propose three different types of users. Actors, who actively participates by interacting with the exhibit. Bystanders or observers, who are aware of the exhibit focally but not actively interacting with the exhibit. And spectators, who are walking around having only a peripheral awareness of the exhibit. Exhibits that are designed to support transitions among these user boundaries are the ones successful in attracting more users to actively participate. To distinguish among different roles the actors are
taking during their interaction with the experiments, I classified them further as leader, helper, player and quitter. The details of this classification have been described in the methods section. I expect to see older children in a group to be leaders and younger children in a group to be observers.

2.6. Expectations based on previous research

The focus of my study is to capture and understand aspects of visitor interaction that might not be visible without thorough video observations of different group member’s behavior while they interact with the experiments. Based on the previous research on group dynamics and learning in science centers, I have some assumptions on the behavioral patterns of the groups that I expect to see on the recorded videos. I explore the group interactions and investigate whether those assumptions are correct or not. While exploring visitors’ interaction with the experiments and their communication with each other, a broader contextual level is also considered in situating those interactions. Building on the literature review, I start with some hypotheses, and then I investigate those by thoroughly examining the recorded videos of the visitor groups while they explore the gamified science center experiments. Finally I present which of these assumptions gets confirmed from the video observations and which of these assumptions turn out to be incorrect.

**Expectation 1:** Adults and teenagers will take lead in cognitive types of experiments for example memory games. While young children will take lead on physical type of experiments for example goalkeeper.

**Expectation 2:** Adults will engage more with guided experiments while young children will engage more with free play, exploring multiple experiments within a short time period without finishing them all.

**Expectation 3:** Older children in a group of multiple children specifically teenagers will take the lead while starting a new experiment.

**Expectation 4:** If an experiment is short and the feedback is immediate, younger children will finish it properly. But if the experiment is long and the feedback is delayed until the experiment is finished, then younger children will prematurely opt out. Resulting in younger children exiting in the middle of a group engagement;

**Expectation 5:** Adults in the group will guide the younger children throughout the engagements.

**Expectation 6:** Adult males and teenagers will dominate others during a group engagement.

3. Method

For my research, I have performed simplified interaction analysis of previously recorded video data to find out who interacts in which order while engaging with the exhibits and connect that to the design of the experiments and the structure of the group to determine what contributes in the emergence of a leader among the members of the group.

3.1. “The Mission” game

The mission is an overarching game designed to provide the science center visitors with a clear path to follow during their visit. This game involves several of the available experiments which has been modified to provide game challenges to the visitors and by participating in this game those visitors
would have a coherent visit experience. These experiments have been equipped with RFID card readers to output reward points for the visitors who are participating in this game. Reward points can be earned by completing an experiment efficiently. Each experiment also has a touch screen interface to guide the visitors during engagements and to provide feedback on their progress. The visitors who want to participate in this game get a RFID card that can be used to collect the reward points throughout their visit. Finally a central game hub gives the visitors an option to redeem their reward points. The target audience of this game is the group of multigenerational families, specifically middle to high school students, their parents and or grand parents. One of the main goals of this game is to increase meaningful collaboration and interaction within groups and to encourage parents and the children to engage collectively while exploring the exhibits.

3.2. Procedure

To understand group engagement or behaviors, video analysis could be an appropriate and powerful tool. I focused my research on video recordings of groups interacting with different experiments at Tom Tits that was collected during a research project in summer 2014 by a group of researchers from Uppsala University. This observational video data was filmed from a first person’s point of view by groups equipped with the camera on one of the group member’s chest. To collect video data, when a group enters the exhibit area of The Mission, researchers approach and inform about the study. If they agree to participate in the study, researchers hand out a consent form, which gets a permission to film them. The researchers help one of the group members equip with a GoPro camera with an external microphone. The group starts to walk around in the exhibition and interact with experiments. When the group finishes exploring The Mission, the camera is taken off and the video is saved for analysis. This objective data can help to understand, in what manners groups experience the exhibition and if there are specific interaction patterns within a group based on their dynamics. I analyze the videos thoroughly by watching them multiple times and by tagging parts of the video when I see any specific behavioral pattern of interest taking place within the group while they engage with different experiments. My aim is to find out which of the expectations listed in background section are fulfilled and which ones are violated based on the video analysis.

3.3. Interaction analysis of video data

Jordan (1992) argues that basic data for theorizing about knowledge in interaction analysis comes from the details of social interactions among members of communities in time and space, instead of the traces of cranial activity like survey or interview data. This provides a strong foundation for analytic knowledge of the world since it comes through verifiable observations. However, common methods to study visitors’ behavior still rely on the visitors’ feedback in form of surveys or interviews where the data is analyzed long after they left the exhibits. In contrast, by analyzing video data and by observing visitors’ interactions as it happens, researcher’s bias toward highlighting part of data as important and passing over parts of data as not important can be avoided. This results in a level of detail that is very hard to achieve by reconstructing events from survey data or interviews. Since the aim of this study is to find out the interaction patterns during group engagements, interaction analysis of recorded video data stands out as the most suitable method for investigating the engagements.

3.4. Experiments being observed during video analysis

The following experiments are part of The Mission game and have been recorded during filming of the project. Group interactions with these experiments are the main focus of my analysis.
**Experiment 1 - Trembling test**

Learning component: The experiment challenges the visitor in their motor skills. The visitor will gain an understanding of electronic closed circuits.

**Description:** The experiment consists of a corrugated or otherwise curved metal rod and a loop around the rod. The challenge is to take the loop from one side to the other with as few touches as possible. While the visitor is interacting with the experiment, he / she can see feedback on the screen about his / her progress.

Type – This experiment focuses on visitor’s physical skills.

Feedback – This experiment provides immediate feedback through the screen.

**Experiment 2 - Laser Puzzle**

Learning component: The visitor will gain an understanding of how light is reflected and lost. This experiment challenges the visitor in logical problem solving skills.

**Description:** The experiment consists of a playing field, where with adjustable prisms and mirrors the visitors have to guide the laser beams to hit the selected target points. The screen provides feedback throughout the engagement. At first five non-illuminated light symbols appear on the screen. For each successfully completed level, one of the light symbol lights up. Hitting a specific number of target points completes a level.

Type – This experiment focuses on visitor’s cognitive skills.
Feedback – This experiment provides delayed feedback since a number of target points need to be hit first to complete a level.

**Experiment 3 - Bridge**

Learning component: The visitor will gain an understanding of the wedge function and how this can be used for vaulting. The experiment involves both problem solving and is a physical challenge for the visitor.

**Description:** This experiment challenges the visitors to build a bridge. The experiment consists of two bridge abutments and a number of wedge-shaped building blocks that can be used to build a bridge between the abutments. After a bridge is built, visitors need to get on top of it to see feedback on their progress provided through the screen.

Figure 3: Family of five interacting with bridge experiment

Type – This experiment focuses both on visitor’s cognitive skills and physical skills.

Feedback – This experiment provides delayed feedback since the bridge needs to be built first.

**Experiment 4 - Light Pavilion**

Learning component: The visitor will gain an understanding of color theory, color characteristics, reflection and absorption of different wavelengths of light. The experiment challenges the visitor in logical problem solving.

**Description:** Light Pavilion consists of a room with different lighting. There are hidden symbols inside the room. The visitor is challenged to respond to the symbols visible inside the bright pavilion. The visitor responds to the challenge by filling in a chart on the screen.

Figure 4: a group of two interacting with light pavilion
Type – This experiment focuses on visitor’s cognitive skills.

Feedback – This experiment provides immediate feedback through the screen.

**Experiment 5 - Cubic Meter**

Learning Component: The participant gets an idea of the volume (how much is a cubic meter) and density.

**Description:** The experiment consists of a cubic meter big box with two doors and "The Mission" screen. The challenge is to get as many people (as much weight) as possible in one cubic meter large "box". Both doors of the box need to be closed properly to earn reward points, which are shown on the screen.

Type – This experiment focuses on visitor’s physical skills.

Feedback – This experiment provides immediate feedback through the screen.

**Experiment 6 - Balance board**

Learning component: The participant learns about balance and an understanding of how your body works with balance.

**Description:** The challenge consists of a balance board and "The Mission" screen that sits in front of the balance board so that the user can see the screen when balances. As long as the board is loaded and balanced, it increases the progress meter visible on the mission screen. When not in balance, or if the participant is holding the rack, a light starts...
blinking with sound so that the visitor sees she is doing it wrong, and the meter stops increasing.

Type – This experiment focuses on visitor’s physical skills.

Feedback – This experiment provides immediate feedback through the screen.

**Experiment 7 - Memory game**

Learning component: The participant gets an idea of and can train their ability to remember things (the brain's working memory).

**Description:** The experiment consists of four large buttons and "The Mission" screen. Initially one of the buttons lights up. When the participant presses that button, two buttons light up in sequence (ie. after the first button the next one flashes in random order). Once the visitor presses those buttons in correct order, the sequence becomes 3 flashes long. The sequence becomes longer and longer, until the participant presses the wrong button in the sequence.

Type – This experiment focuses on visitor’s cognitive skills.

Feedback – This experiment provides delayed feedback a sequence needs to be completed first to see progress.

**Experiment 8 - The Goalkeeper**

Learning Component: The visitor will gain an understanding of human reaction speed and body movement / coordination, as well as train the memory, execution and cooperation (in more difficult levels).

**Description:** The challenge consists of a wall (about 2m high, 3m wide) with a number (about 16) of buttons (a button is about 10cm diameter), and "The Mission" screen. The buttons light up one by one as the participant presses the current button in the sequence. Initially, the pattern is easy to predict, but becomes
increasingly complicated and eventually several buttons light up simultaneously. To achieve maximum points, the participant must probably work with others.

Type – This experiment focuses on visitor’s physical skills.

Feedback – This experiment provides immediate feedback on the screen with a progress meter and time remaining.

**Experiment 9 - Mirror writing**

Learning component: The visitor will gain an understanding of optics, as well as hand-eye coordination.

**Description**: The visitor has to follow the given pattern as closely as possible on a landscape screen with a digital pen just by looking at the screen in the mirror. Visitor's drawing hand is hidden and only the mirror image can be seen. When the first pattern is completed, the progress meter on the screen increases and the next pattern is shown on the mirror that needs to be drawn using the digital pen.

Type – This experiment focuses on visitor’s physical skills.

Feedback – This experiment provides delayed feedback since a pattern needs to be completed first to see the progress meter increase.

**Game Center: The central hub of The Mission game**

**Description**: Game Center consists of a multi-touch screen and a number of RFID readers. It brings together everything related to The Mission game. The visitors can see which positions they are at, what they have completed and what they still have left to do. The visitors can choose to register their team. However, this is optional, they can also play as a guest. This is the hub where visitors can use the reward points they have accumulated throughout their engagements with different experiments by identifying themselves with their RFID card. Those reward points can be used to accessorize a virtual aircraft that can be launched by tapping on the touch screen. The more the reward points the more accessories that become available for use. The visitor can choose to launch their aircraft or to go out in the exhibit area again to continue collecting more reward points.
3.5. **Observations from the video data**

Most of the recorded videos begin just before the group enters the mission game area and end when they are done interacting with the experiments and redeemed their reward points on the game center terminal. The duration of these videos are thirty minutes or longer, which makes these a bit too complicated for continuous interaction analysis. To keep the focus on the leadership of the groups during their interaction with different experiments, each video was divided into multiple observations, where each observation begins when the first person of the group starts interacting with an experiment; and the observation ends when the last person of the group leaves that experiment. In this way the video data was divided into manageable observations and those observations were analyzed thoroughly to focus on interaction patterns of the groups. During the observations, the following tags were used to point out important interaction patterns observed in the video data. Same tags can be applied to multiple observations while multiple tags can be applied to the same observation. These tags help to identify interaction patterns in the group currently being observed.

3.6. **Description of tags used for video observation**

These tags were developed and used during the observations of video data. Each tag reveals an important factor identified during a group’s engagement with an experiment.

- **Leader** – The group member who (at the time of observation) enters or leaves the experiment first
- **Helper** – The group member who (at the time of observation) helps the leader
- **Observer** – The group member who (at the time of observation) observes others
- **Player** – The group member who (at the time of observation) engages with the experiment after the leader has already engaged
**Quitter** – The group member who (at the time of observation) opts out from an experiment prematurely

**Single player affordance** – Only one person can interact with this experiment at a time. The experiment design affords a single person; others in the group need to wait.

**Multiplayer affordance** – Multiple people can interact with this experiment at the same time. The experiment design affords more than one person and expects members in a group to work together.

**Focused on physical skills** – Design of the experiment requires the visitors to use their physical skills

**Focused on cognitive skills** - Design of the experiment requires the visitors to use their cognitive skills

For each observation, I watched that segment of the video multiple times, each time focusing on a different member of the group to analyze his or her interaction pattern during the engagement with an experiment. Observed behavior was then written down in the analytical tables listed in the results section. Those tables have been further analyzed in the analysis section.

### 4. Result

The following table describes the structure of six different groups of visitors who participated in the recorded video sessions.

<table>
<thead>
<tr>
<th>Group number</th>
<th>Members</th>
<th>Group structure</th>
<th>Video session length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Four</td>
<td>Adult female, adult male, teenage girl, younger boy</td>
<td>42 minutes 43 seconds</td>
</tr>
<tr>
<td>2</td>
<td>Three</td>
<td>Adult male, two girls approximately the ages between 8 to 12</td>
<td>17 minutes 45 seconds</td>
</tr>
<tr>
<td>3</td>
<td>Two</td>
<td>Two adult females</td>
<td>28 minutes 10 seconds</td>
</tr>
<tr>
<td>4</td>
<td>Four</td>
<td>Adult female, adult male, teenage boy, younger boy</td>
<td>61 minutes 48 seconds</td>
</tr>
<tr>
<td>5</td>
<td>Four</td>
<td>Adult female, adult male, two boys approximately the ages between 6 to 8</td>
<td>30 minutes 40 seconds</td>
</tr>
<tr>
<td>6</td>
<td>Four</td>
<td>Adult male, teenage girl, two boys approximately the ages between 4 to 6</td>
<td>36 minutes 50 seconds</td>
</tr>
</tbody>
</table>
The focus of these observations was to find out what determines, who is taking the lead in that group while they interact with different types of experiments in the mission game. The next six tables describe the patterns of interactions observed for these groups from the recorded video data. The first column lists the name of the experiment that has been described in the methods section. The second column describes the behavior of different group members observed during the engagement. This description helps to determine who is taking the lead during that engagement. The third column lists the member of the group taking the lead during that engagement. On the fourth column, the contributing factors or tags that apply to that observation have been listed. These tags help to determine any interaction pattern that stands out from that engagement of that group. The last column has been derived from the combination of the first four columns’ data; it lists any interaction pattern identified during the video analysis. These patterns have been compared with the expectations listed in the background section. These contextual level descriptions of interaction patterns help to pin point the factors contributing in the decision of the leadership for a group. These verifiable observations provide details that are much richer than group’s feedbacks through interviews and questionnaires. These tables are further analyzed in the analysis section to discuss the observed interaction patterns in details.

**Group 1 – adult female, adult male, teenage girl, younger boy**

<table>
<thead>
<tr>
<th>Experiment name</th>
<th>Description of observed engagement</th>
<th>Who is taking lead</th>
<th>Contributing factors (tags)</th>
<th>Observed interaction pattern</th>
</tr>
</thead>
</table>
| Balance board   | Group gathers around the experiment  
|                 | Teenage girl takes the lead and goes first  
|                 | Adult male acts as the helper, taps the rewards card and counts down to the start of the experiment  
|                 | All four members of the group takes their turn to complete the experiment multiple times to get the best score | Teenage girl | Teenage girl as group leader, adult male as helper, single player affordance | Fulfills expectation 3 |
| Laser puzzle    | Young boy approaches the experiment already in progress  
|                 | Teenage girl takes the lead and directs the laser beam  
<p>|                 | Adult male and adult female participate and work as helpers | Teenage girl | Teenage girl as group leader, adult male and adult female as helpers, young boy as observer, multi player | Fulfills expectation 3, Violates expectation 5, Fulfills expectation 6 |</p>
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Description</th>
<th>Leader</th>
<th>Players</th>
<th>Affordance</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goalkeeper</td>
<td>Young boy runs to the experiment, takes the lead and start playing</td>
<td>Young boy</td>
<td>Young boy as leader, other members of the group as player, multiplayer affordance, focused on physical skills</td>
<td>Fulfills expectation 2</td>
<td></td>
</tr>
<tr>
<td>Memory game</td>
<td>Group approaches the experiment</td>
<td>Teenage girl</td>
<td>Teenage girl as leader, adult female as helper, young boy as observer, single player affordance, focused on cognitive skills</td>
<td>Fulfills expectation 1</td>
<td></td>
</tr>
<tr>
<td>Cubic meter</td>
<td>Young boy walks passed the trembling test experiment, gives it a try, moves on to the cubic</td>
<td>Adult male and teenage</td>
<td>Adult male as leader, teenage girl as helper,</td>
<td>Fulfills expectation 2</td>
<td></td>
</tr>
</tbody>
</table>
**Adult male engages with the cubic meter experiment, teenage girl joins in**

Adult male and teenage girl complete the experiment and collect the reward points

Young boy gets in to the box but gives up after a few seconds and moves on to the next experiment following the adult male

---

**Group 2 – adult male, two girls approximately the ages between 8 to 12**

<table>
<thead>
<tr>
<th>Experiment name</th>
<th>Description of observed engagement</th>
<th>Who is taking lead</th>
<th>Contributing factors (tags)</th>
<th>Observed interaction pattern</th>
</tr>
</thead>
</table>
| Trembling test  | Younger girl freely walks around through the exhibit area  
Older girl in the group walks to the trembling test experiment and starts interacting  
Younger girl and adult male observe the engagement  
Older girl finishes the experiment  
Younger girl picks up the metal loop and tries to engage with the experiment  
Younger girl gets frustrated in the middle of the engagement with her progress and quits, the older girl takes over  
Younger girl walks away from that area and moves to the balance board experiment | Older girl in the group | Older girl as leader, adult male as observer, younger girl as quitter, single player affordance, focused on physical skills | Fulfills expectation 3  
Fulfills expectation 4  
Violates expectation 5 |
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Action Description</th>
<th>Role Description</th>
<th>Expectation Fulfilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance board</td>
<td>Younger girl approaches the experiment</td>
<td>Adult male as quitter, younger girl as player, single player affordance, focused on physical skills,</td>
<td>Fulfills expectation 1, Fulfills expectation 4</td>
</tr>
<tr>
<td></td>
<td>Adult male of the group already started engaging with the experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Younger girl takes over from the adult male</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult male steps aside and observes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Younger girl finishes the experiment and walks away</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory game</td>
<td>Younger girl walks to the experiment and start playing in the middle of a gameplay left by some other group</td>
<td>Younger girl as quitter, focused on cognitive skills</td>
<td>Fulfills expectation 2, Fulfills expectation 4</td>
</tr>
<tr>
<td></td>
<td>After a few moments she gets frustrated with the progress and exits the experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser puzzle</td>
<td>Younger girl moves on to the laser puzzle experiment</td>
<td>Older girl as leader, younger girl as observer, single player affordance, focused on cognitive skills</td>
<td>Fulfills expectation 2</td>
</tr>
<tr>
<td></td>
<td>Older girl of the group is already interacting with the experiment</td>
<td></td>
<td>Fulfills expectation 3</td>
</tr>
<tr>
<td></td>
<td>Younger girl observes for a few moments and then moves on to the goalkeeper experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal keeper</td>
<td>Younger girl in the group approaches the experiment and starts interacting right away</td>
<td>Younger girl as leader, older girl as player, adult male as observer, focused on physical skills, multiplayer affordance</td>
<td>Fulfills expectation 2, Fulfills expectation 4, Violates expectation 5</td>
</tr>
<tr>
<td></td>
<td>Older girl in the group joins in</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult male stays on the side and observes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both of the girls play together to finish the experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>Older girl tries to collect the reward points</td>
<td>Younger girl restarts the experiment</td>
<td>Both of the girls play again and finish the experiment</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Bridge Cubic meter</td>
<td>Younger girl in the group walks to the Bridge experiment</td>
<td>She observes other groups interacting with the experiment</td>
<td>She walks away and moves to the cubic meter experiment</td>
</tr>
<tr>
<td>Write mirror</td>
<td>Younger girl of the group approaches the write mirror experiment and starts interacting</td>
<td>She stays engaged with the experiments for couple of minutes</td>
<td>She gets frustrated with the progress and exits in the middle of engagement</td>
</tr>
<tr>
<td>Multiple experiments</td>
<td>Younger girl of the group walks to the Trembling test experiment for the second time</td>
<td>She engages with the trembling test experiment for a few minutes and then quickly walks</td>
<td>Younger girl in the group</td>
</tr>
</tbody>
</table>
to the cubic meter experiment
The younger girl joins the adult male and the older girl in the group who are already engaging with the cubic meter experiment
The youngest girl spends a few moments in that experiment and then walks back to the trembling test experiment for the third time
She engages with the trembling test experiment for a few moments but exits in the middle of engagement
Leadership is unknown cause the camera did not capture the interaction between adult male and older girl

<table>
<thead>
<tr>
<th>Group 3 – Two adult females</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment name</strong></td>
</tr>
<tr>
<td>Goal keeper</td>
</tr>
<tr>
<td>Experiment</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Write mirror</td>
</tr>
<tr>
<td>Cubic meter</td>
</tr>
<tr>
<td>Bridge</td>
</tr>
</tbody>
</table>
experiment
One of the group members walks on top of the bridge and collect the reward points
The group moves on

Laser puzzle
The group approaches the laser puzzle experiment
Both of the adult females of the group stand on different sides of the table and start engaging with the experiment
They finish the experiment together, collect the points and walks away

<table>
<thead>
<tr>
<th>Experiment name</th>
<th>Description of observed engagement</th>
<th>Who is taking lead</th>
<th>Contributing factors (tags)</th>
<th>Observed interaction pattern</th>
</tr>
</thead>
</table>
| Balance board  | The group of four gathers around the balance board experiment  
Teenage boy of the group gets on the board and start engaging with the experiment  
Younger boy observes the interaction and tries to understand the experiment  
Teenage boy finishes the experiment and gets off the board  
Younger boy gets on the board and start interacting with the experiment, teenage boy guides him from the side  
Younger boy finishes the experiment | Teenage boy | Teenage boy as leader, younger boy as player, single player affordance, focused on physical skills | Fulfills expectation 3 |

Group 4 – adult female, adult male, teenage boy, younger boy
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Description</th>
<th>Player</th>
<th>Player Description</th>
<th>Affordance Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laser puzzle</td>
<td>Both of the boys walk towards the next experiment. Teenage boy of the group points at the laser puzzle experiment, picks up a mirror and start interacting with the experiment. Younger boy joins in from the other side of the table. Teenage boy guides him through the whole experiment. Both of the boys finish the experiment together. Teenage boy collects the rewards points. Both of the boys move on.</td>
<td>Teenage boy</td>
<td>Teenage boy as leader, younger boy as helper, multiplayer affordance</td>
<td>Fulfills expectation 3, Fulfills expectation 6</td>
<td></td>
</tr>
<tr>
<td>Trembling test</td>
<td>Teenage boy walks to the trembling test experiment. Teenage boy picks up the loop and starts interacting. Younger boy observes until the teenage boy is halfway through. Teenage boy hands over the loop to the younger boy. Younger boy starts in the middle of the experiment and finishes it. Both of them start walking towards the next experiment.</td>
<td>Teenage boy</td>
<td>Teenage boy as leader, younger boy as player, single player affordance</td>
<td>Fulfills expectation 3</td>
<td></td>
</tr>
<tr>
<td>Bridge</td>
<td>Teenage boy walks toward the bridge experiment. Teenage boy picks up a big piece of the bridge block and start building the experiment. Younger boy joins in and start engaging with the experiment. By the time younger boy places</td>
<td>Teenage boy</td>
<td>Teenage boy as leader, younger boy as player, multiplayer affordance, focused on physical skills</td>
<td>Fulfills expectation 3, Fulfills expectation 6</td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>Action 1</td>
<td>Action 2</td>
<td>Fulfillment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory game</td>
<td>Teenage boy and the younger boy walks to the experiment</td>
<td>Teenage boy as leader, younger boy as helper, single player affordance, focused on cognitive skills</td>
<td>Fulfills expectation 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage boy sits down as soon as the last group leaves the experiment</td>
<td></td>
<td>Fulfills expectation 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage boy starts interacting with the experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Younger boy helps him with the pattern from the side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage boy finishes the experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both of them moves on</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goalkeeper</td>
<td>Teenage boy points at the goalkeeper experiment</td>
<td>Younger boy as the leader, teenage boy as player, multiplayer affordance, focused on physical skills</td>
<td>Fulfills expectation 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Younger boy runs to the experiment, gets on the left side and starts interacting</td>
<td></td>
<td>Fulfills expectation 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage boy joins in from the other end of the wall</td>
<td></td>
<td>Fulfills expectation 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage boy instructs the younger boy throughout the experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both of them play together and finish the experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>They collect the reward points and start walking away</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light pavilion</td>
<td>Teenage boy approaches the light pavilion experiment</td>
<td>Teenage boy as leader, younger boy as</td>
<td>Fulfills expectation 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experiment name</td>
<td>Description of observed engagement</td>
<td>Who is taking lead</td>
<td>Contributing factors (tags)</td>
<td>Observed interaction pattern</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------</td>
<td>-------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| Write mirror    | The group of four walks to the write mirror experiment  
Adult male of the group picks up the pen and shows the older one of the two boys how to use it  
The younger boy of the group takes the pen and interacts with the experiment  
Older boy observes for sometime and walks away from the experiment and walks to the balance board | Adult male | Adult male as leader, younger boy as player, older boy as observer, single player affordance, focused on physical skills | Fulfills expectation 1 |
| Balance board   | Older boy gets on the balance board, interacts with it for a few moments until the other members of the group show up  
Older boy gets down from the board and observes other members of the group engaging with it  
He decides to walk away from the experiment and go back to the write mirror | Older boy | Older boy as quitter, other members of the group as player, single player affordance | Fulfills expectation 2  
Fulfills expectation 4  
Violates expectation 5 |
<table>
<thead>
<tr>
<th>Old</th>
<th>Event</th>
<th>Activity</th>
<th>Role</th>
<th>Affordance</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write mirror</td>
<td>Older boy interacts with the write mirror experiment for a few moments but exits in the middle of the experiment</td>
<td>He walks back to the balance board experiment and observes the adult male interacting with the experiment</td>
<td>Adult male</td>
<td>Multiplayer affordance, focused on cognitive skills</td>
<td>Fulfills expectation 6</td>
</tr>
<tr>
<td></td>
<td>Once the adult male gets off the board, the older boy gets on the board again and interacts with the experiment for a few moments</td>
<td>He exists in the middle of the experiment and walks with the group to the next experiment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridge</td>
<td>The group walks to the bridge</td>
<td>Adult male of the group picks up a piece and start building</td>
<td>Adult male as leader, other members as players</td>
<td>Fulfills expectation 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult female of the group joins in and start building</td>
<td>Both of the boys observe for sometime and join in</td>
<td>multiplayer affordance, focused on cognitive skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The group work together and finish the experiment</td>
<td>All four members of the group gets on the bridge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>They collect the reward points and moves to the next experiment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trembling test</td>
<td>The group approaches the trembling test experiment</td>
<td>Older boy as the quitter, younger boy as player</td>
<td>Older boy</td>
<td>Fulfills expectation 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Older boy of the group picks up the loop and start interacting</td>
<td>single player affordance</td>
<td></td>
<td>Fulfills expectation 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>He gives up in the middle of the experiment and hands it over to the younger boy of the group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Memory game
Younger boy continues with the trembling test experiment
Older boy walks to the memory game experiment, interacts with it for a few moments, gives up and returns to the trembling test to observe others interacting with the experiment

<table>
<thead>
<tr>
<th>Group 6 – adult male, teenage girl, two boys approximately the ages between 4 to 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment name</strong></td>
</tr>
</tbody>
</table>
| Laser puzzle | Young boy joins the group of four gathered around the laser puzzle table  
Teenage girl is interacting with the puzzle  
Adult male and the other young boy are observing  
Young boy observes the interaction for sometime and then joins starts engaging with the experiment  
Other young boy also joins in  
Teenage girl tries to collect reward points at the end of the experiment but gets confused where to place the RF card  
One of the researcher comes to the table and shows the group how to collect the points  
Teenage girl collects the points but decides to play again  
Teenage girl and the two young boys of the group interact with | Teenage girl | Teenage girl as leader, young boys as player, adult male as observer, multiplayer affordance | Fulfills expectation 3  
Violates expectation 5  
Fulfills expectation 6 |
<table>
<thead>
<tr>
<th>Stage</th>
<th>Activity</th>
<th>Participants</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge</td>
<td>The group walks to the bridge experiment</td>
<td>Teenage girl and adult male try to start a new experiment using the screen.</td>
<td>Fulfills expectation 3</td>
</tr>
<tr>
<td></td>
<td>Two young boys of the group walk on top of the bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage girl and adult male try to start a new experiment using the screen.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Since the bridge was already built by the previous group, screen keeps instructing to dissemble the bridge first.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teenage girl takes the pieces apart and starts to rebuild.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both of the young boys join in and help with the building.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>They build the bridge together under the teenage girl’s guidance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Both of the young boys get on top of the bridge and collect reward points.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The group walks to the next experiment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goalkeeper</td>
<td>Young boy of the group runs to the goalkeeper experiment.</td>
<td>Young boy runs all over the wall and finish the experiment all by himself.</td>
<td>Fulfills expectation 1</td>
</tr>
<tr>
<td></td>
<td>He starts interacting with the experiment right away without waiting for the rest of the group.</td>
<td>He walks away from the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fulfills expectation 4</td>
</tr>
</tbody>
</table>
experiment and joins the rest of the group

<table>
<thead>
<tr>
<th>Balance board</th>
</tr>
</thead>
<tbody>
<tr>
<td>In both of these cases, teenage girl of the group engages with the experiment while the rest of the group observes the interaction</td>
</tr>
<tr>
<td>Teenage girl</td>
</tr>
<tr>
<td>Teenage girl as leader, adult male and younger boys as observers, single player affordance</td>
</tr>
<tr>
<td>Fulfills expectation 1</td>
</tr>
<tr>
<td>Fulfills expectation 3</td>
</tr>
</tbody>
</table>

### 5. Analysis

To find out the answers for my sub-questions of this research study, I thoroughly analyzed the results tables listed above for each group and tried to pinpoint any patterns converging from it. It’s clear from the observations that many of the behavioral patterns match with the expectations I came out with during the literature review. Since my focus was to find out what determines who is taking the lead; I analyzed only the data that’s directly relevant to that decision.

For group 1, it’s clear that the teenage girl of that group is taking the lead in most cases while entering and exiting an experiment. She is the oldest among the children in that group and age seems to be having an important role in determining who is taking the lead. As for the design aspects of the experiments, teenage girl is taking the lead in guided cognitive skill based experiments, while the only time youngest child in the group is taking the lead is the goalkeeper experiment which requires physical skills and offers immediate feedback. We also see the young boy as quitter for multiple experiments since he opts out of those experiments prematurely.

As for group 2, the results are quite different. In this case the youngest girl in the group is taking the lead in most cases while entering and exiting an experiment. However, she is not finishing those experiments properly. She is more interested in free exploration of multiple experiments instead of taking the time to finish individual ones. In the recorded data, she is walking around through the exhibit area most of the time while other members of the group are interacting with the experiments. Leader is unknown for those experiments because camera did not capture those interactions among other group members. Here we see the younger child of the group mostly exploring freely opting out from multiple experiments prematurely. She might have been more interested in those experiments if the adult in that group was providing guidance during the engagements and there were more immediate feedback from the experiments to keep that child engaged. From this observation we see young children taking the lead if an experiment requires physical skills instead of cognitive skills and quitting in the middle of an experiment if the experiment is long and the feedback from that experiment is not immediate for that child. We also see the younger child as a quitter in most of the engagements due to her age, lack of immediate feedback from the experiments and the lack of guidance from the adult in the group.

Group 3 is a bit exceptional group consisting of two adult women. While analyzing the results for this group I noticed a lot of cooperation between the members of the group. They were taking turns in finishing the experiment properly. They went through the experiments one by one and only moved on to the next experiment after they finished the previous one. None of the members engaged in free exploration and none of them opted out of an experiment in the middle of engagement. They also made sure to take the reward points after each experiment was finished. This fulfills the expectation
that adults are more likely to finish guided experiments and cooperate with each other during group engagements.

Group 4 mirrors the results of group 1. Just like group 1 this group has a teenage boy and a younger child in the group, and in most of the cases the teenage boy takes the lead entering and exiting an experiment. The only time this pattern changes is in the case of goalkeeper experiment where the youngest boy in the group takes the lead. Here again we see the effect of age of the children in the group and physical skills based free play design aspect of an experiment. Same as the first group, the teenager in the group is taking the lead and dominating during group engagements and the youngest child is exploring freely taking the lead only in the case where immediate feedback is provided.

Group 5 has two young boys aged between six to eight. Both of the boys, specially the older one run around from one experiment to the next spending only a few minutes on each. He tries out multiple experiments without finishing any of them properly. Here again we see the same pattern of free play among young children. They tend to exit in the middle of guided experiments that need cognitive skills and don’t provide immediate feedback. Age is having a significant influence here, since both of the young children are prematurely opting out of the experiments that are designed for a higher age group.

The teenage girl in the group takes the leadership of group 6. She takes lead by entering and exiting first in most of the experiments. The only exception is the goalkeeper experiment where the youngest boy of that group takes the lead. Age of members of the group and design of the experiments play a big role again in determining who takes the lead in that group while they interact with different experiments throughout the exhibit area. Teenagers are taking the lead once again during group interactions.

If we combine the findings for all the six groups, we see different patterns arising from the observations. First of all, if there is a teenager in a group then in all cases that teenager takes the lead and dominates during group interactions. This observation is consistent for all types of experiments except for the goalkeeper, where we see the youngest member of the group taking the lead in all cases.

Secondly, adults in those groups are surprisingly not involved in providing guidance in most cases. They tend to let young children explore freely instead of guiding them through different experiments. Even though it’s expected that those adults will take the lead during interaction with complex experiments that need cognitive skills, in most cases they just act as observers or helpers while someone else in the group takes the lead.

Finally, most of the time young children of the groups become bystanders just exploring the space and standing around others to observe their interaction with the experiments. If the experiment design demands cognitive skills then young children tend to become observers and try to understand how it works. In most of the cases they opt out prematurely from these experiments due to their less developed cognitive and motor skills and lack of guidance from the adults. This is also true for experiments that don’t provide enough feedback to keep them interested. If an experiment involves mostly physical activity, then young children of the group want to interact with it freely without any specific guidance from the adults, they become the leaders and they expect immediate feedback; any delay in the feedback make them frustrated and they would just quit and find something else that looks fun to play with.
After analyzing the observed behavior from the recorded videos, I suggest both the structure of the group and the design aspects of the experiment itself determine who takes the lead while interacting with an experiment during group engagements. Specifically, age of the group members plays an important role during a group engagement. Also whether an experiment requires cognitive skills or physical skills during interactions and whether it provides immediate feedback or delayed feedback, these design aspects of an experiment play a vital role on the decision of leadership when a group approaches to interact with that experiment.

6. Conclusions

One of the most important findings of this study is the documentation of the observed behavioral patterns of multigenerational groups in the context of a gamified science center. From the results section of this study we can clearly identify multiple patterns of behavior based on the structure of the group and design of the experiments.

By focusing explicitly on the group dynamics during the engagement with an experiment and observing who is taking the lead in different scenarios, it’s clear that the structure of a group has a strong effect on group interactions. Specifically, age plays an important role if a group has multiple children. Teenagers tend to take the lead and dominate during those engagements, while young children tend to explore freely. Even with the addition of interactivity and game elements on the experiments, young children are still being less thorough exploring the space that matches with findings of previous research that didn’t involve gamification or interactivity (Schauble et al., 1991). Young children are also opting out prematurely when there’s not enough guidance or feedback provided, which also matches the results of earlier research by Dunbar & Klahr (1988). Not much has changed even with the implementation of touch screens interfaces. I suggest increasing the amount of feedback provided through those screens. By decreasing the delay in feedback and adding more rewarding animations, young children can be kept interested throughout the engagements. This should decrease the premature opt outs.

Another important finding of this study, is the effect of the design of an experiment on the interactions of the group. It’s observed in multiple groups that the youngest child in the group is much more interested in free exploration and experiments focused on physical skills rather than experiments focused on cognitive skills. They are driven mainly by their intrinsic motivation of the joy of play than the extrinsic motivation of reward points from the gamified experiments. Young children tend to take the lead in engagements where they are not bound by the rules of the game. They like to make their own rules and run around through the exhibit area.

Furthermore, its noted from this study that adults of the groups don’t engage much in teaching roles for the group when a scientific experiment needs an explanation. They act more like helpers or observers during a group interaction. This affects the learning abilities of the children in the group since all these experiments are based on scientific phenomena and adults are expected to guide them when they are not clear about the basis of any experiment. It’s observed from the videos that the adults are more interested in letting the children play freely than being a guide throughout their visit.

In summary, I have shown that age of the members of a group, the skillset (physical vs cognitive) needed for interactions with an experiment and the amount of feedback (immediate vs delayed) provided by an experiment play a vital role in determining who is taking the lead while a multigenerational group interacts with different experiments in a gamified science center. These
results are not unexpected in any way, the unexpected finding in this study is the role of adults, whom I expected to be more involved during the engagements and take the leadership when the younger members of the group needed guidance.

6.1. **Limitations**

Due to the small and homogenous sample size used in this qualitative study, no claims can be made towards the broad generalizability of the findings. In the qualitative viewpoint, the collection of data, observation of the video material and analysis was done thoroughly and carefully; but the findings do not claim reliability in a statistical way. To avoid author's bias over the findings, a second observer was engaged to review some of the video materials and the findings from both observers aligned with each other; but a well-documented method for establishing expert agreement would be needed to completely avoid any sort of bias. Another limitation is the lack of continuous data collection and analysis over a long period of time until no new data appear from the observations and the results have been confirmed to be well grounded.

6.2. **Ethical considerations**

Like any other qualitative studies, ethical concerns were one of the top priorities during this study. To deal with the ethical questions that arise from video based observations, informed consents were taken from the groups participated during the data collection phase. It was also taken into consideration who might be most vulnerable during the recording phase and cautions were taken to make sure no harms come to them due to the research. Confidentiality is also important in video based work. Measures were taken to make sure only the researchers who need access to the video data can review the videos, on one else were allowed access to the video material. Finally, video based data is considered a powerful record of people’s behavior that can be used in additional ways outside of the scope of the research. During this study, it was made sure the data has been accessed only for the purpose of this research and those video materials were not used for any other purposes.

6.3. **Future research**

In the future, many aspects of the observed interactions can be investigated further. The role of adults in a group needs to be studied in depth. In this study, I observed the adults staying on the sideline most of the time instead of leading the group or guiding other members when needed. It will be interesting to find out the reasons behind this type of behavior. Also, the amount of feedback provided by the experiments during the engagements can be thoroughly examined to see how the premature opt out rate of young children can be decreased.

7. **References**


