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Quest-driven exploration of interactive installations in science centres

QUEST-DRIVEN EXPLORATION OF INTERACTIVE INSTALLATIONS IN SCIENCE CENTRES

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Abstract

This study examines quest-driven exploration of interactive installations at two science centres, the first being Universeum science center and the second being the visitor centre of Onsala Space Observatory. The argument for using quests is based on lowering thresholds to informal learning of scientific concepts through self-guided exploration. The study results in a classification of quest-based exploration in four types of quests and a set of guidelines for using quests as a method for lowering thresholds and raising engagement for different target groups. The discussion highlights the effectiveness of using quests for informal learning of STEM subjects through exploration in primary and secondary education. We conclude that the method to use quest-driven exploration contributes to lowering thresholds and raising engagement in the scientific topics presented. The classification in four types creates a framework for science centre design that can be used by designers and pedagogues in the development of learning activities.

Keywords: Exploration, informal learning, science centre, interaction design, science communication, method, evaluation, STEM.

1 INTRODUCTION

Science centres play an important role in providing opportunities for visitors to interact with scientific phenomena and learn through hands-on experiences. Interaction and learning are closely linked concepts, and research has shown that interactive exhibits can significantly enhance visitors' learning experiences. Interactive exhibits provide opportunities for visitors to engage in active exploration, experimentation, and problem-solving, leading to a deeper understanding of scientific concepts [1].

Science centres are important informal learning environments aiming at interaction with scientific knowledge. However, not all interactive exhibits are equally effective, and the design and implementation of interactive exhibits can significantly impact visitors' learning outcomes [2]. The challenge for science centres is to open up for interaction, enable further exploration, and create meaningful experiences for visitors of the intended target groups. Our research has identified a need to lower the threshold for visitors to start interacting with installations, as well as methods and best practices on how to work with these thresholds.

Informal learning through exploration is a key component of the visitor experience in science centers. Visitors engage with exhibits and other educational resources in a self-directed manner, leading to unique learning outcomes that differ from more traditional classroom-based instruction. Visitors also come in different constellations, such as exploring individually or exploring in groups with varying sizes, and some through personal visits and others through structured visits such as school visits, all which has an impact on their exploration as well as their learning [3].

Research in the past decade has shown that informal learning through exploration can significantly impact visitors' attitudes toward science and their scientific literacy. For example, a study by Falk and Dierking [5] found that science center visitors who engaged in more exploration reported greater gains in science-related knowledge and a greater interest in science. Furthermore, studies have also shown that the benefits of informal learning through exploration extend beyond the time of the visit, with visitors demonstrating increased engagement with science-related media and continued interest in science [6][7]. Exploration-based learning can also be beneficial for visitors from diverse backgrounds, including those with limited prior scientific knowledge. For example, a study by Abaci et al. [4] found that visitors with low prior knowledge demonstrated greater learning gains through exploration-based learning than through guided tours.

2 PURPOSE AND AIM

In this paper, four types of quest-based methods for exploring interactive installations at science centres are presented. The classification in types is based on a range of implemented and tested exploratory exhibits in three different learning environments. This research builds on recent studies on learning processes, gamification, and interaction in science centres [8].

We aim to provide methods and best practices for quest-driven exploration in science centres as a complement to traditional texts, guided tours, and audio-guides as ways to increase visitor engagement, learning, and science capital.

This study is based on a science capital approach [9], aiming at understanding how people's attitudes, experiences, and resources shape their engagement with science. The approach recognizes that individuals bring with them their personal backgrounds, identities, and social contexts, which influence their perceptions of science and their willingness to engage with it. The science capital approach emphasizes the importance of broadening participation in science by building on visitors' science-related experiences, interests, knowledge and practices. It also highlights the need for science education to be more inclusive and to recognize and value diverse perspectives and experiences.

3 METHODOLOGY

There are various methods for testing learning and interaction at science centers, which have been widely discussed and researched in the last decade. For this study, we have chosen to observe visitor behavior, which can provide insights into how visitors interact with exhibits and the learning outcomes they derive. We also use interviews and surveys to collect qualitative and quantitative data directly from relevant stakeholders such as personnel and visitors at science centres. Furthermore, we use involvement of our target group of children and teenagers both in co-creation workshops of quest design, as well as for user testing, to learn more on the wants and needs of adolescents. These methods are supported by various studies, including Falk and Dierking's "The Museum Experience Revisited" [10] and Bitgood et al's "Exhibit design and visitor behavior" [11].

The study is separated into two phases. The first phase was conducted at an exhibition called Vislab, at the Gothenburg science centre *Universeum* (Fig. 1). The exhibition addresses sustainability as a topic in the following five areas: at Sea, on Land, in Society, in Space, and the Human body, in which the visitor can explore each topic through interactive screen installations. This part of the study used research-through-design [12] as a method to gain insights on how quest-driven design could increase visitor interaction. This means that knowledge was gained through designing a quest game. The process included traditional iterative steps of interaction design methodology: research, ideation, prototyping, and evaluation [13] focus was primarily on visitors that attended the exhibition on their own initiative, both visitors that came alone or with others, as opposed to guided tours or school workshops. The quest game built on individual interaction, as well as social interaction emerging from individual interaction, two out of the four different types of interactive exhibits identified by Karlén [14].

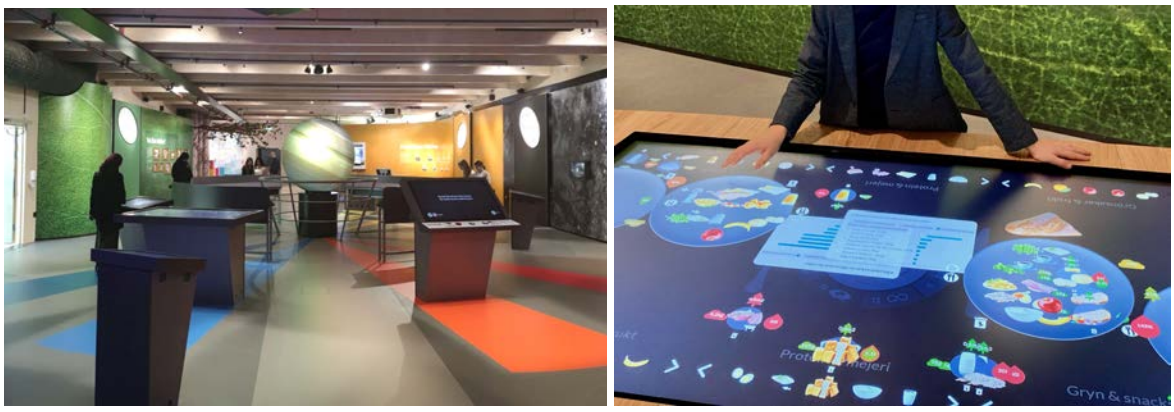

Figure 1: The VisLab learning environment (left) and a user interacting with the Food On The Table installation (right).

The second part of the study was conducted at the newly-opened visitor centre at a research facility, *Onsala Space Observatory* (Fig. 2). Here also we applied design methodology, this time putting the learnings gained at Universeum into practice when creating quests to increase interaction for the new environment. Here, we tested quest-driven activity cards with school classes on arrival at the observatory's visitor centre during a guided tour. Here we also wanted to explore Karléns third exhibit type, Social interaction emerging from collaboration. We created a set of 25 activity descriptions which we tested in a series of five half-hour sessions with classes of different ages (from 8 up to 17), modifying the tasks and design between sessions. We also tested the tasks at a public event with participation from adults and children in 3 half-hour sessions, and with two groups of senior citizens.

Figure 2: The Onsala Space Observatory visitor center exhibition (left) and a user interacting with the How Big Are Things In The Universe installation (right).

4 RESULTS

The first phase of the study resulted in the development of two quest-driven exploration games, a digital quest game called VisQuest, as well as an analog paper quest game. VisQuest is a mobile game that the visitor starts in the VisLab environment and gives the user a set of quests to choose from. The paper quest game consists of a set of cards that the visitors pick freely during a designated group activity.

Evaluation of the prototypes of these games resulted in categories of quests, based on levels of users' personal reflections vs finding facts, as well as degrees of freedom for the users when doing the different tasks. Through our research a classification of four quest types was created and tested through the quest games in both study cases:

- **Self-examination:** making the visitors use the exhibits to find out something personal or unique related to them.
- **Quiz:** answering fact-based questions with one or more correct answers, where the answers can be found somewhere in the exhibit.
- **Activity:** performing a certain activity at an exhibit, which does not require the visitors to input an answer.
- **Discussion:** sharing thoughts, reflections and opinions about a particular topic or question.

See examples of quests for the study at Universeum (Fig. 3) and for Onsala Space Observatory (Fig. 4)

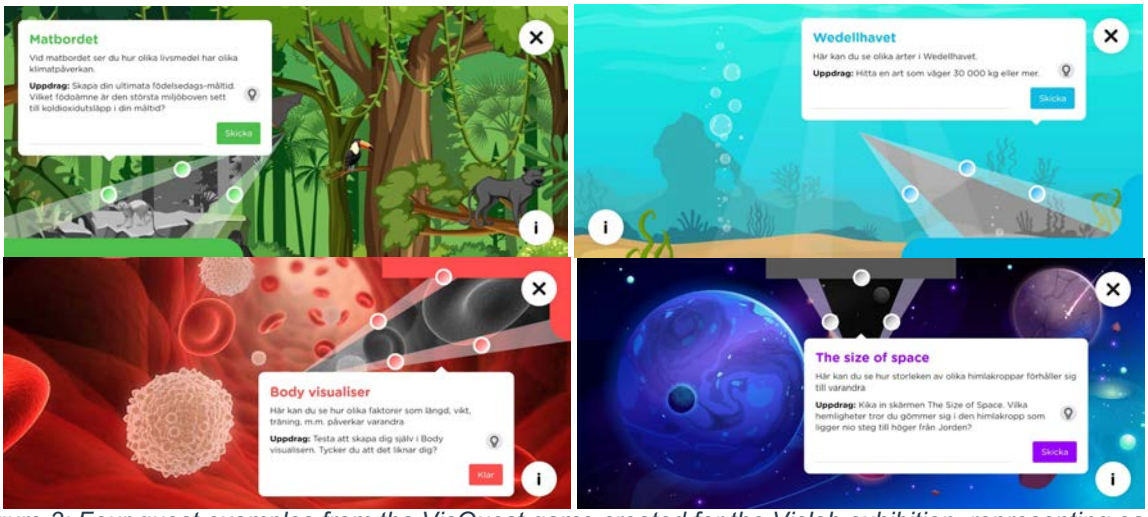

Figure 3: Four quest examples from the VisQuest game created for the Vislab exhibition, representing each quest type.

1. *An example of a Self-examination quest.* ***Translation****: At the dinner table (name of the exhibit) you can see how different foods have different effects on the climate. Quest: Create your ultimate birthday-meal. Which food is the biggest climate culprit in your meal?*
2. *An example of a Quiz quest.* ***Translation****: Here you can see different species in the Wedell sea. Quest: Find a species that weighs 30 000kg or more.*
3. *An example of an Activity quest.* ***Translation****: Here you can see how different factors such as height, weight, exercise, etc. affect each other. Quest: Try creating yourself in the Body visualiser (name of the exhibit). Do you think it looks like you?*
4. *An example of a Discussion quest.* ***Translation****: Here you can see how the sizes of different celestial bodies relate to each other. Quest: Check out the screen The Size of Space (name of the exhibit). What secrets do you think hide within the celestial body nine steps to the right of the Earth?*

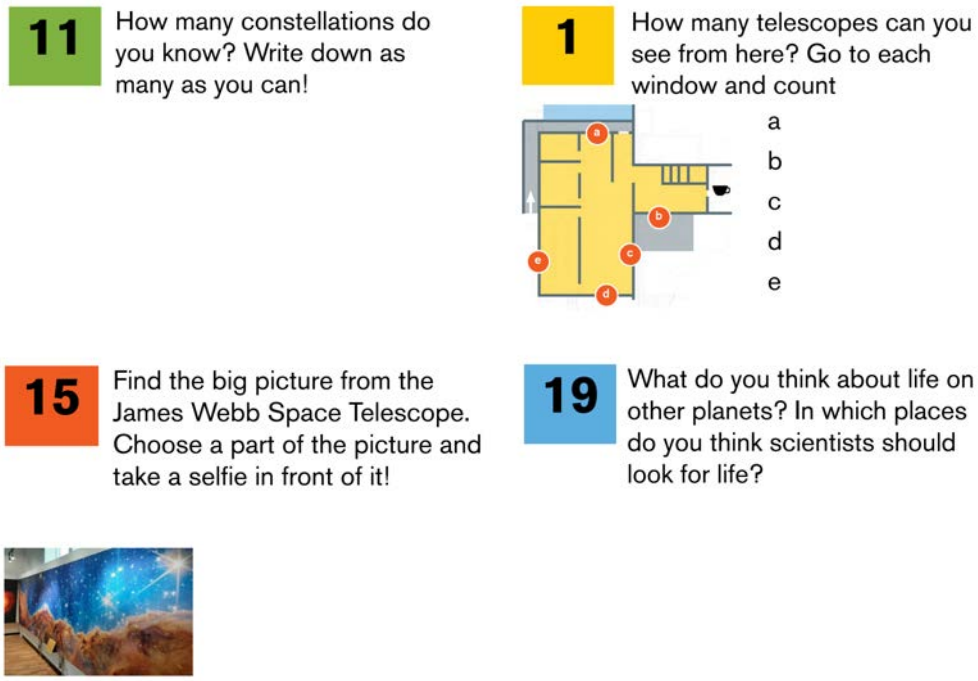

Figure 4: Four quest examples made for the exhibition at Onsala Space Observatory using variation in use of quest types. Green (11) represents the Self-examination type. Yellow (1) represents the Quiz type, Red (15) represents the Activity type, and Blue (19) represents the Discussion type. To some extents, the types are combined, so that 11 has an element of Quiz, and 1 has an element of Activity.

To evaluate how well quests increased interaction, user tests were made in each exhibition with visitors. At Universeum, user tests were made inside the exhibition area by comparing both users and non-users of the quest through them answering the same survey. The survey included questions of how long they visited the exhibition, how many individual exhibit's they interacted with and which ones. 26 participants aged 11-27 participated, and the result showed that people exploring the exhibition with quests stayed more than 4 times longer than that of a non-user. It was also shown that non-users on average engaged with 2 exhibits, while quest-users interacted with 10 exhibits (see Table 1). Thus, the user tests showed that quests increased initial engagement and overall made the visitors engage longer with the exhibition.

	Non-user span	***Non-user average***	***User span***	***User average***
Number of exhibits tested	1-3	2	5-18	10
Visit duration (minutes)	2:00 – 10:00	4:00	15:00 – 20:00	17:30

Table 1: Data from user tests made at Vislab, comparing results from both users of quests in the VisQuest game, and non-users of quests. The span data refers to the range of answers collected, e.g. non-users interacted on the lowest with 1 exhibit, and the non-user participant with highest interactions interacted with 3.

At Onsala Space Observatory, our evidence collection was less formal. The guide(s) on duty observed visitor behaviour, collected used activity cards, and noted feedback from visitors in the form of questions and comments. Based on experience with visits without using the cards, we were also able to compare visitor response to the concept

For school classes from year 6 through high school, the activity cards occupy visitors in exploring the exhibition's content, apparently making their exploration more effective. Younger visitors tended to seek assistance from adults in order to understand the tasks, and were more prone to give up, for example if they couldn't find a location referred to in the task.

We judged success by identifying tasks which were more often completed than others, and with some groups we also asked at the end of the session which tasks were most enjoyable. Among more popular tasks were those which involved actions (playing a space-themed Memory game, throwing stones into a pool) and some form of self-examination (measuring how much you weigh on different planets, counting visible telescopes from windows). The discussion-related questions we tested (soliciting ideas for finding alien life, or what you would do as minister for space) were less popular, though they created some opportunities for visitors to contact the guide and ask for clarification.

Through our research we also derived a set of guidelines for designing quests in an exhibition setting, which are the following:

- Use a variety of quest types for your exhibition. Having a mix of the aforementioned quest types is beneficial for making people stay engaged for longer.
- Make use of Self-examination quests: focus on creating and using Self-examination quests. Note that this does not mean that you should not solely have Self-examination quests, you should still have a variety of quest types. However, we found that Self-examination quests were the most effective type of quest for getting users to engage with the exhibits, so featuring them more prominently might be worthwhile.
- Have some form of reward: give visitors some reward for completing quests. This can serve as a good motivator to complete quests and engage with your exhibition.
- Cater to a variety of target groups: make sure that the quests are appropriate for people of all ages, skill levels, etc. of the people that visit your exhibition. Your quests should have different difficulty levels and require different amounts of knowledge for the visitor to complete.
- Include some form of competition: design your quests in such a way that it is possible for visitors to compete. Competing with one's friends can be a great motivator to complete quests and is also a way for visitors to have more fun in the process.

5 DISCUSSION

Our observations show that visitors get engaged in the scientific content by quest-based exploration. Even though the results show that some types of quests are more popular than others, this does not mean that the less popular are less important. More visitors picked Self-examination quests than Discussion quests, but there are some visitors that can spend a long time imagining what life on other planets might look like or discussing the size of the universe. The informal learning processes connected to those deeper thoughts are at least as important as finding facts about the world and oneself.

Visitors from primary vs secondary education interact differently as groups, however on an individual level there are large differences within the groups. This is a strong argument for using quest-based exploration, where the freedom of choice between different types of quest can stimulate different types of learning and create a palette of experiences. Even though there are general thresholds to overcome for engaging students in STEM subjects, there are also individual hinders and triggers for creating interest and engagement.

Social interaction is an important dimension of informal learning in the science center context. This can be used as an advantage when playing a game in groups or individually but next to others. However, for visitors exploring a learning environment through quests working in groups, there is always the risk of group pressure affecting the possibility for free choice and exploration.

The learning processes in a science center is highly dependent on interaction with physical and digital installations, and therefore affected by the design of these interfaces. In our study, we have used a wide range of media, such as physical cards, mobile games, touch screens, physical objects, and other tangible interfaces. It is inevitable that how well these interfaces are designed affect the visitors' exploration and the evaluation of the quests. However, it is clear that quest-based exploration provides an opportunity to combine physical and digital parts into a whole experience that can bridge the physical-digital divide.

The results from the survey at Universeum indicate that the quests were effective for making visitors stay longer at and engage more with the exhibits. The visit duration increased by more than 4 times and the number of exhibits interacted with increased by 5 times. However, these results come from a limited sample size, and some of the increase in visit duration and exhibits interacted with can be attributed to variance.

There is also the question of causality. Visitors who completed quests stayed for longer at the exhibits than visitors who explored the exhibits without any quests. A potential explanation for this could be that some people were already more interested in the exhibition to begin with, hence they completed quests and thus the people who would have stayed longer at the exhibits anyway became a part of the quest-users part of the study group.

Furthermore, although the quests made visitors engage more with the exhibits, the results from the study may be affected by how the quests are presented. In the study for Vislab, the quests were presented by researchers explicitly and actively to visitors. This may have made visitors complete quests for the sake of the study, and not because of their own interest. However, during the evaluation the app was presented as something to use during one's visit and not to be the focus of their visit, and the survey was presented as optional. This could indicate that the results were not affected much, since the purpose of their visit continued to be their own free exploration.

Moreover, they may not even have begun completing quests if someone hadn't presented the quests for them. This raises the question of how the quests should be presented to visitors. On one hand, one would want to present them clearly to visitors so that there is a greater chance for them to find out what the quests are. On the other, one would not want to be too intrusive and risk scaring away potential visitors by overwhelming them with something they might not be interested in.

Ethically, a study like this raises questions. Apart from respecting the test persons' integrity, there are more complex aspects to consider. Who gains and who loses from a quest-based approach to learning science? Is it reasonable to provide so much resource to learning environments that are not accessible to everyone? We believe that these sorts of questions need to be addressed in all research that strives to improve these exclusive learning environments that science centres can be. A transformation of learning methods must be combined with aspects of accessibility.

6 CONCLUSIONS

The evaluation of our tests shows that the method to use quest-driven exploration contributes to lowering thresholds and raising engagement in the scientific topics presented. The classification in four types creates a framework for science centre design that can be used by designers and educators in the development of learning activities. Future work includes more testing and evaluation, as well as the possibility to add more types and subtypes to the classification.

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REFERENCES

[1] Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (Eds.). (2009). Learning science in informal environments: People, places, and pursuits. National Academies Press.

[2] Chen, X., & Lawrenz, F. (2014). The impact of interactive science exhibits on student learning. Journal of Science Education and Technology, 23(4), 497-509.

[3] A. Ynnerman, P. Ljung, and A. Bock (2020). Reaching broad audiences from a science center or museum setting, Foundations of Data Visualization. Springer, 341–364.

[4] Abaci, S., Kao, Y.-C., Brewe, E., & Burkhardt, A. (2015). Exploring the Effect of Informal Science Education on Low Prior Knowledge Visitors' Interest, Understanding and Learning of Science. Journal of Research in Science Teaching, 52(1), 81-105.

[5] Falk, J. H., & Dierking, L. D. (2010). The 95 Percent Solution: School is not where most Americans Learn Most of their Science. American Scientist, 98(6), 486-493.

[6] Falk, J. H., Storksdieck, M., Dierking, L. D., & Penuel, W. R. (2016). Investigating public science interest and understanding: evidence for the importance of free-choice learning. PloS one, 11(12), e0167263.

[7] Hsin, C. T., Hsu, Y. S., Tsai, C. C., & Wu, H. K. (2019). Exploring the long-term impacts of science museum visitation on science learning. International Journal of Science Education, 41(2), 155-174.

[8] Wideström, J., “Designing for science center exhibitions - a classification framework for the interaction,” Proceedings of the Design Society: DESIGN Conference, vol. 1, p. 1657–1666, 2020.

[9] Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). Science capital: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of research in science teaching, 52(7), 922-948.

[10] Falk, J. H., & Dierking, L. D. (2012). The Contextual Model of Learning. The Museum Experience Revisited.

[11] Bitgood, S., Patterson, D., & Benefield, A. (1988). Exhibit design and visitor behavior: Empirical relationships. *Environment and behavior*, *20*(4), 474-491.

[12] John Zimmerman, Jodi Forlizzi, and Shelley Evenson (2007). Research through design as a method for interaction design research in HCI. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07). Association for Computing Machinery, New York, NY, USA, 493–502. https://doi.org/10.1145/1240624.1240704

[13] J. Preece, Y. Rogers, and H. Sharp (2015). Beyond Human-Computer Interaction, 4th ed. Wiley.

[14] Karlén, J. (2017), Learning with Digital Tools on Public Knowledge Institutions, A Literature Review based on Grounded Theory, Göteborg University. Report, Vol. 2017 No. 106, pp. 36