SOS Museum, a Gamified Learning App for Cultural Heritage Preservation Tailored for School Visits: Observational Insights

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Abstract: - This paper intends to systematize a first quantitative study based on the frequency of observable behaviors related to the implementation of a gamified mobile app built to raise awareness about risk management and preservation issues at the Military Museum of Porto, Portugal. The purpose of this study was to acknowledge, compare, and analyze the behavioral changes of a group of students (n=84) aged between 8 to 12 years old divided into two groups: experimental and control. Obtained results will assist a deeper and future analysis addressing infocommunicational problems in gamification processes and their relationship with knowledge in the museum context. The first results show that, by comparison to the control group, visitors were more excited, had more sense of urgency, were mutually aiding each other, and had more efficient communication and collaboration by completing tasks quickly and effectively, throughout the 30-minute average duration of the experience.

Key-Words: - Cultural heritage, preservation, observable behaviors frequencies, mobile gamified application, observational registry, experience.

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1 Introduction – From Learning to the Interactive Experience Model

Museums have become complex entities shaped by multiple dimensions. In the 21st century museums have evolved into spaces of cultural and educational mediation [1], strongly oriented towards surrounding communities [2]. Associated with non-formal education, museums try to shape and deliver activities that potentiate learning, frequently trying to amplify knowledge about their collections and related present or past pertinent subjects. When dwelling on learning, the concept is a very complex principle to grasp. Nevertheless, a way to describe it revolves around an active assimilation process of information within personal, social, and physical contexts, incorporating the accommodation of new information into mental structures and enabling its use, but learning can also be defined in a markedly political manner where dialogue plays a primary role. According to [3], educator and author, the learning process is marked by underlying transformations that occur through the construction of knowledge, which may be transmitted when the object of study is truly comprehended and assimilated, [3]. Also learning, whether concrete or abstract, should be viewed as a holistic approach, based on a central cycle of experience that results in a combination of perception, cognition, and behavior, [4]. Although individuals learn better when they are highly motivated, negative motivations can also promote learning but over time and with repetition, retention might diminish, [5]. Additionally, it is crucial to emphasize that emotions play a significant role in cognition, overlapping with motivation, problem-solving, decision making, and consciousness, whereas without their influence, learning wouldn´t be possible, [5]. Considering this, learning processes are based on individual choices that heavily depend on emotions, because “sensory perception and attention, both of which play key roles in learning, are highly influenced by emotions due to changes in the neurotransmitters released in the brain”, [6]. Therefore, learning always infers a behavioral, physical, or mental alteration in individuals that originate a medium to long-term retention of information and the use of a series of specific and personal attributes linked to comprehension, motivations, perceptions, and different contexts.

Given the frequency of educational activities in museum institutions and all their diversity, facilitating the measurement of learning entails an extremely complex process. One of the strategies that should be employed, similar to the formal educational system, involves delineating the specific learning objectives of each activity, and ensuring their fulfillment. Nonetheless, this fulfillment does not imply that there has been, in fact, knowledge retention by the participants, other measures to assess results are necessary depending on the type of activity.

In the book "The Museum Experience"[7] it is proposed an interactive experience model where three contexts - personal, social, and physical - which contribute significantly to visitors' perception, assimilation and potential learning, are outlined. According to the authors [7], there is a misconception that learning is solely the acquisition of new ideas, facts, or formally received information, but its complexity derives from multiple situations, spanning from schools to museums, amongst other spaces, and it is closely connected to individual memory and perception.
The ability to use, recognize, solve problems, recall images, smells, sounds, colors, or memorize choreographies involves the use of perception and integration into memory for future use [7], but also learning itself can be considered as a socially mediated group activity, directly influencing individuals' roles and relationships permanently with many social, emotional and even intellectual competencies acquired through the modulation of others' behavior. Thus, it is worth noting that learning processes also occur within a physical context, which is of utmost importance when determining how much information is perceived and recalled, [7]. The continuous interaction between these three contexts (personal, social, and physical) makes up the ultimate experience because, based on findings, a well-balanced experience that accommodates correctly these three contexts has a better chance of being remembered in the long term, [7]. Nonetheless, it should be emphasized that behavior in museums is often reactive, unconscious and responsive to space, color and forms, but visitors do not retain visual memories of objects, captions, or conceptual schemes, but rather events and observations that they categorize into mental and personal lists, determined by events experienced before and after visiting, [8]. Consequently, museum visitors have a variety of motivations, expectations, and beliefs that affect or may affect learning and the visit itself, which should always be taken into account.

This paper aims to synthesize a first approach to the analysis of observational occurrences during the implementation of a digital gamified prototype – SOS Museum – aimed to address preservation issues within the Military Museum of Porto, in Portugal. In the observational grid construction, we intended to mirror the interactive experience model [7], where we formulated constructs [9] to optimize observed behaviors during the life span of the experience inside the museum, [10]. Observable behavior frequencies were measured within an experimental group that tested SOS Museum, as well as within a control group that visited the exhibition, addressing the same learning objectives as the ones developed in the mobile app. The presented results show that the experimental group had a more enjoyable and emotional interaction because the experience is well balanced in the personal and social context in comparison with the control group. However, certain disparities in the physical context may be attributed to the distracting nature of the mobile app itself. Nonetheless, this does not necessarily imply a lack of visitor engagement with the museum space and collections, on the contrary, emotionally driven behaviors seem to prove otherwise.

2 SOS Museum: An App to Promote Awareness about Risk and Preservation in Museums

The introduction of new technologies in museum spaces has, in a way, shaken up access to information throughout museological institutions, a paradigm that the new museology [11] had already witnessed and foreseen, enabling experiences within and for communities. Delivering new forms of connecting with these communities now requires clear and distinct content that should address the target group's needs and characteristics. During the project, we sought out methods to achieve this aim and found that leveraging gamification strategies could strengthen the communication of information by fostering engagement and enjoyment. Given that the intended audience for this proposal consisted of children aged from 8 to 12 years old, gamification was perceived as a means to streamline access to information and enhance its availability through engaging and educational "game-like structures," thereby possibly impacting learning.

Our gamified application – SOS Museum – is centered around the preservation and safeguarding of cultural assets in the Military Museum of Porto, Portugal. This choice was made primarily because it constitutes a major task within museum teams and, secondly, because it introduces children to a novel subject they can learn from. We believe that gamification strategies can help to empower visitors as active agents in risk management, forging a close connection with the issue, which could be beneficial in the long run for forming new museum audiences. The introduction of game mechanisms was aligned to promote a deeper understanding of some preservation processes, relying upon an age-appropriate narrative. Equally important was the selection of objects within the museum space to ensure users' physical integration into the gamified experience. With that in mind, our objects' selection aimed to establish an immediate connection through the identification of materials and characteristics, encouraging the visitor's observation and detection competencies. SOS Museum integrated solutions involve quizzes, an exhibition plan tour and game-like simulations of three risk contexts (earthquake, moth activity, and incorrect light, temperature, and relative humidity) which instills a sense of urgency by motivating users to make decisions. Also, the application was created taking into consideration specific learning outcomes to be achieved during progression, such as: facilitating a better understanding regarding the vulnerability to physical forces, light, temperature, and relative humidity, the vulnerability of textiles to insects and a better understanding of the need to articulate curatorship and preservation within museums' spaces. Moreover, feedback mechanisms were included in the design of the experience [12], as well as game mechanisms, such as points and badges that reinforce desired actions and introduce freedom and surprise, making the experience possibly more creative and enriching.

3 Direct Observation: Grid Construction and Registry

3.1 Methodology

The prototype evaluation at the museum engaged a total of 84 students, aged between 8 and 12 years old, from four classes: two from the fourth grade and two from the fifth grade. The process began by dividing each class into two distinct groups: an experimental group and a control group. In the experimental group, students engaged with the gamified digital prototype, forming teams of 2 up to 4 users per mobile device, as the gamified experience requires. Conversely, the control group (Figure 1) embarked on a distinct guided tour focused on learning objectives related to preservation issues, akin to those in the application. Observational data was meticulously live noted and coded (Figure 1), deploying two observational grids per class, totaling eight equal grids. The observational grid was tailored specifically for this evaluation, capturing behavioral dynamics both with the application and throughout the guided tour. Each grid was filled in by the researcher according to a pre-established counting protocol per time block. Included observable behaviors in the grid derived from well-thought-out decompositions of more complex concepts [13], allowing an appropriate identification without significant inquiries. Grid results were tabulated as frequencies and subsequently converted into graphs using integrated tools available in Excel for a more effective comparison between groups and contexts over time.

Fig. 1: Half a 5th grade class doing the normal visit - Control Group coding, ©Bárbara Andrez, 2024

3.2 Grid Construction

The designed observational grid aimed to gauge the frequency of behaviors in both groups, drawing from the interactive experience model [7], which categorizes the dimensions of visitors into three primary contexts: personal, social and physical. Thus, to further unpack these contexts into typologies of observable behavior, the initial step involved selecting and developing constructs [9] or indicators within each context: excitement, initiative, happiness and sense of urgency – within the personal context; problem-solving and listening ability – within the social context; and lastly, spatial movement – within the physical context.

After identifying these constructs, we began to unfold them into sets of potential observable behaviors, considering that these variables were built upon group dynamics taking into account minimal external fluctuations, [9]. Nevertheless, this doesn't rule out the possibility of uncontrolled external factors, especially within each student's personal context, that can alter the visit itself, regardless of the attributed group (experimental or control), resulting in fewer frequencies per grid.

With that in mind, sets of observable behaviors marked under excitement were: speech acceleration; changes in the tone of voice; animated facial expressions and the use of positive and/or exclamatory verbal expressions like “amazing”, “fantastic” and “love it”. Under initiative and urgency, sets of marked observable behaviors were grouped under beginning tasks or engaging in discussions or movement and carrying out actions rapidly, whereas behaviors such as talking before anyone else or getting ahead of the group were coded. Related to the social context and under problem-solving, we marked as a set mutual aid and effective communication and collaboration in completing tasks quickly and effectively where behaviors such as attention to what others are doing or expressions such as “I´ll do it", “Worry not”, “Let’s win” were coded, amongst others frequencies. Under listening ability, no interruption, nods, or neutral facial expressions when someone speaks were marked and coded. Finally, within the physical context and spatial movement we have chosen attention to the objects in the museum collection and the reading of objects’ informative captions. In addition, we introduced some notes for each set of observable behaviors, for instance, the attention to the objects was coded whenever there were glazes directed towards objects or fingers pointing. These notes made it quicker to code, and, when in doubt, they provided examples of behaviors adding more accuracy to the frequency marking. Also, because we believe that verbal expression is of utmost importance, this observational grid didn’t solely rely upon the observational competencies of the researcher. Instead, there are several behaviors marked that rely only upon the researcher’s attention and listening abilities.

3.3 Observational Registry

Since the observation was conducted in groups continuously, a rapid marking frequency system was implemented whenever any of the listed behaviors were detected within the group. To streamline the marking process, the duration of the sessions was carefully timed and observations were organized into five-minute blocks to track behavior progression over time. Observed behaviors were coded within the corresponding time block; for instance, if a change in voice pitch occurred 2 minutes into the session, the coding and marking would be attributed to the 5-minute block. Similarly, if the behavior occurred at the 17th-minute mark, it would be noted in the 20-minute block, as the block's name designates the maximum time limit.

Due to the high cost associated with observational measurement, in terms of time and demanding attention, competency, and judgment requirements, various alternatives exist to divide observation sessions and mitigate expenses. In this particular case, observations were conducted live and solely by a single researcher, without video capture to streamline subsequent review. So, by doing a continuous behavior sampling method by event [9] we have simplified the collected observational occurrences, making it easy to code and mark frequencies of behavior as they were happening. We believe that this organization made observational behavior coding possible with the accuracy and attention that is expected for a single researcher in this particular setup.

4 Analysis and Results

After concluding all sessions, we aggregated the total frequencies alongside their corresponding time blocks and observed behaviors. The data obtained hinges upon comparing two distinct groups—the experimental and control group—over time and across various contexts of observable behavior, a primary objective of this project. However, we acknowledge that the data obtained during sessions was selective, as it's impractical to encompass all facets of observable behavior and code them in a non-selective manner, [13].

The inquiries we sought to address were: how is the frequency distributed across each context over time in the two groups? Are there significant temporal changes in frequencies between the two groups? And are the experiences robust across all three contexts? Drawing from the interactive experience model [7], the challenge of this study was to create an observational grid outcome based on quantitative analysis, allowing us to discern how both experiences operate distinctively over time, as illustrated in the accompanying graphics (Figure 2 and Figure 3).

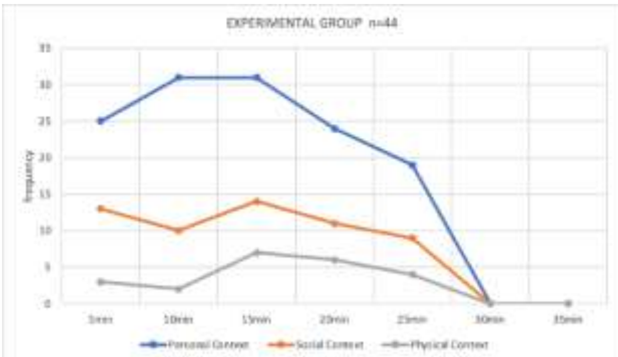

Fig. 2: Experimental Group three contexts outcomes

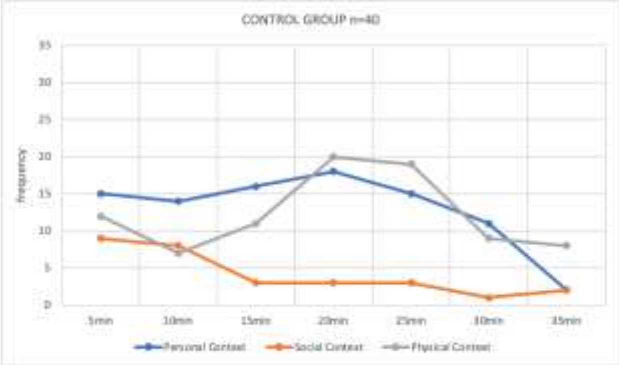

Fig. 3: Control Group three contexts outcomes

Several key observations stand out initially. Firstly, it's important to highlight that the duration of the multiple sessions was not uniform. The control group, relying on a traditional visit, lasted longer on average (between 35 to 40 minutes), while the experimental group concluded their experience in around 30 minutes or less. This discrepancy arose from two uncontrollable factors: firstly, the allocated museum professional spent more time exploring themes and spaces within the museum, and secondly, because the experimental group was always the last one to go, we faced time constraints imposed by school teachers. Consequently, while most students in the experimental group finished within the allotted time, two teams had to be rushed through due to time restrictions. Additionally, it's noteworthy that the sample compositions were not identical. Two students who were supposed to be part of the group visit (n=40) ended up testing the application (n=44) due to a calculation error during their separation upon arrival at the museum. Despite these variations, we can still discern significant differences when comparing the obtained graphics.

One notable distinction is that all three contexts exhibit significant changes over time during the experience. In the experimental group, the personal context is notably heightened compared to the other two, indicating that the gamified app was well-received, engaging, and enjoyable. In the social context, albeit with fewer occurrences, we observe that social interactions integrated into the application, such as team dynamics and element swapping, functioned effectively as social engagement tools that persisted over time despite some natural fluctuations. Conversely, in the physical context, the experimental group exhibits fewer occurrences (Figure 2). We hypothesize that this is due to the high demand for personal investment and because of the digital nature of the experience itself (mobile app). With that in mind, students may have become immersed in the experience, possibly losing track of their surroundings and objects as they navigated through the app, but there are still a few peaks over time that can be closely connected with the app's challenges and prompts, such as analyzing objects and reading captions.

Upon examining the control group (Figure 3), we noticed that the physical context is more prevalent, surpassing the other two that seem to decline over time, midway through the experience. This suggests a sudden interest in the objects or a diminishing interest in the spoken content, prompting visitors to seek novelty in order to pursue or maintain engagement. Nevertheless, a comparison of both graphics reveals a more balanced relationship between contexts in the experimental group, potentially indicating a well-rounded experience [7], which is essential for long-term knowledge retention, by contrast, in the control group, each context seems to rely on its own. Also, the experimental group displays a closer relationship between the three contexts, although not formally tested, whereas this relationship appears to be less pronounced in the control group.

When juxtaposing the personal context within the same graphic (Figure 4), we observe a gradual decline in both groups over time, reaching zero around the 30-minute mark in the experimental group due to the experience concluding earlier than the average duration of the control group. Moreover, a notable trend emerges as there is nearly double the frequency of behaviors within the first 15 minutes, indicating heightened engagement at the onset of the experience, which diminishes as participants hurry towards its conclusion.

Fig. 4: Personal context in the control group and experimental group

On the other side, the control group exhibits smaller fluctuations, with significantly fewer behavioral occurrences, suggesting instances where group engagement has been improved by the museum professional to maintain their attention over time. It is believed that the experimental group was more emotionally invested in the experience, in contrast to the control group, which had to be pushed and motivated throughout.

Regarding social context, there's a noteworthy contrast between the groups (Figure 5), likely attributed to the playful nature of the application and the inherent need for teamwork and peer interaction. Behaviors coded within the experimental group appear consistently more effective throughout the visit compared to those in the control group, which initially started strong but gradually diminished. We assume that, although all groups stood in the museum space as social entities, the gamified mobile app reinforced some of the group capacities that deal with mutual aid and effective communication and collaboration, where several expressions like “We´ll do it again" and “Let’s move” were listening.

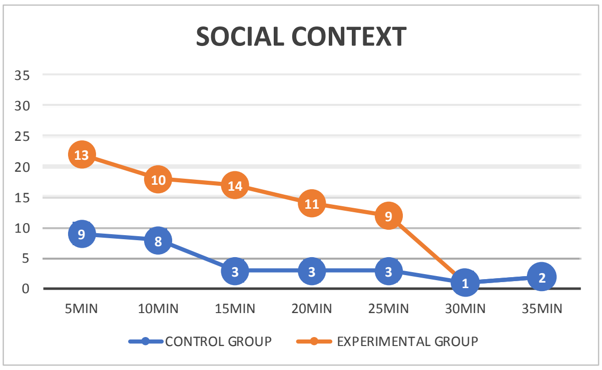

Fig. 5: Social context in the control group and experimental group

Finally, the most significant disparity lies within the physical context of both groups. Figure 6 shows notable differences between the control and experimental groups. However, it's intriguing to note that observable physical behaviors in the control group peak around the 20-minute mark. This coincides with the point where the museum professional had directed the control groups toward a major collection of small toys’ soldiers, spending considerable time in multiple rooms dedicated to this collection until nearly the end of the experience. Given this, it's reasonable to suggest that there may have been a momentary interest in the objects that waned over time.

In contrast, concerning the experimental group, it's similarly apparent that there is a close relation with peaks in the 15-minute and 20-minute mark coinciding with the app requirements to examine highlighted objects in the museum space in order to respond to quiz questions and tackle challenges. It is considered that, although the app has managed small peak attention to objects, the nature of the mobile app itself has imposed lesser physical behaviors occurrences, such as looking at captions or glancing, in comparison with the control group moving alongside the museum professional. This interpersonal relation between the group and the allocated museum professional instantly enhances a more representative physical connection, as Figure 6 shows, because there are immediate associations between the spoken word and the materialized objects on display, resulting in greater frequencies. Nevertheless, we believe, based on the results, that the app has not only contributed to physical engagement, when needed but also to spatial awareness because the teams had figured out how to move through the building on their own.

Fig. 6: Physical context in the control group and experimental group

5 Conclusions and Further Work

This study was important to preview some initial insights regarding observable behaviors of children aged from 8 to 12 years old during the implementation and evaluation of the app SOS Museum. Presented data demonstrates that the experimental group had a more enjoyable and engaging experience, both within personal and social contexts in comparison to the control group, even though both experiences have the same theme and objectives and were delivered for the same exhibition spaces. Also, it is safe to say that, in the experimental group, coded frequencies are more stable and revolve throughout time in a more similar way, even though the physical context behaviors show fewer frequencies. Results show that visitors who have experienced the museum spaces with the app could, drawing from findings [7], potentially retain more information about preservation and safeguarding, because, despite the obtained physical context values, the curves are more balanced than the ones from the guided visit, which is a good indicator of a well-rounded and balanced experience delivery. Nevertheless, it is still necessary to analyze and validate a set of questionnaires which will assist in concluding if, in fact, any form of knowledge retention has occurred in this group.

In the control group, frequencies are more distressed showing a lack of socially observable behaviors, which could undermine knowledge retention. Learning is a socially mediated group activity that heavily influences emotional and intellectual competencies. Therefore, a distinct lack of social context frequencies could annihilate learning if not well balanced. Also, it's important to mention that the scarcity of occurrences in the physical context of the experimental group is due to the nature of the experience itself as a mobile-oriented app. Results reveal that corresponding peaks in the physical context address times when the app ordered visitors, to find objects or acknowledge and assess their material for e.g. In the control group, corresponding peaks in the physical context signal a more vivid interaction with the objects because they are novelty (the case of the tiny soldiers' exhibition rooms), but we have also observed and marked as further notes a shortage of attention in some peak's minute mark that led to wanderers around each room as the museum professional was speaking, that might have contributed to the augmented number of frequencies as well. Considering these results, it is believed that observable behaviors have validated the app as an engaging tool for young visitors, facilitating a range of emotions and positive social interactions throughout the 30-minute experience.

As future work, the app could reunite more forms of engaging with museum collections in order to amplify frequencies of behaviors regarding the attention to objects and reading the objects 'captions. In a contextualized form, we have also come to the conclusion that structuring guided tour visits for this type of target group should be well-planned, in order to articulate all three contexts systematically, regardless of the theme. Nonetheless, it is also worth noting that both experiences in their three contexts start with a high number of frequencies that diminish over time, as novelty disappears or the initial questions are diluted. However, this study demonstrated that a planned introduction of gamification strategies could actually strengthen communication, fostering engagement between peers and enjoyment, irrespective of the theme.

Further work involves analyzing additional approaches, to attest if there is significant knowledge retention over time in the two groups. Based on these results, we assert that a finely tuned gamified experience has the potential to enhance visitors' learning capacities. This might be evident from the observable behaviors in both personal and social contexts, suggesting that such strategies could foster greater knowledge retention compared to a traditional museum visit.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Bárbara Andrez, has conducted the design of the app, as well as the investigation process, data collection/visualization and written draft.

Paula Menino Homem, has supervised the research, prepared the draft to be published, gave feedback and made revisions.

Maria Manuela Pinto, has oversighted the research planning and execution, made commentary and revisions.

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Conflict of Interest

The authors have no conflicts of interest to declare.