Smart City Learning: Qualitative Analysis of Interaction, Interactivity and Multimedia Usage in Outdoor Science Exhibitions Using Body Senses

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Abstract. Smart city learning happens in outdoors. Outdoor science exhibitions are intended to motivate future generations of scientists and engineers. In this paper, we present a qualitative analysis of the exhibitions presented at the Science and Technology Exposition in the State of Querétaro, focusing on interaction, multimedia usage and perceived interest. A framework of measures related to the interest, interaction and interactivity levels is presented in terms of the body senses according to the type of exhibition analyzed. Also, some issues regarding interactive exhibitions are presented, and conclusions of multimedia and interactivity in cultural or scientific exhibitions are drawn, remarking the lack of modern human – computer interaction technologies such as interactive surfaces, virtual reality, augmented reality and brain – computer interfaces. To the authors knowledge this is a first study evaluating interaction in outdoor science exhibitions.

Keywords: HCI, STEM, informal science education, outdoor education, EXPOCYTEQ, Smart City Learning.

1 Introduction

Several organizations have agreed that the most imposing problems the world is facing cannot be resolved without developing capacity to find and take advantage of the appropriate technologies [1][2][3][6][7]. Furthermore, education in science, technology and innovation (STI) is considered the base for the future of economic and social growth. Initiatives in many countries are evidence of the concern in encouraging advances in STI, focusing more specifically in science, technology, engineering and mathematics (STEM). Scientific and technological exhibitions in museums have been taken up with the aim of stimulating STEM education. Science and technology fairs are another way to do it. Both are commonly used by schools to complement the theoretical teaching and learning experiences when they do not have access to such infrastructures.

Modern science and technology museums have interactive exhibits, with some of them including virtual or augmented reality (VR/AR) technologies merged with emerging tracking technologies and other types of human – computer interaction (HCI) devices for more immersive and adaptive scenarios. The rationale behind this is that such exhibits are more attractive and have better impact in stimulating STEM education than traditional exhibits. Thus, observation and analysis of such oriented activities allows us to envision improvement areas and opportunities to introduce new technological and interaction paradigms. However, according to our research, we have not found any previous study evaluating interactivity in such environments.

In this paper, we present a qualitative analysis of the interaction presented in the exhibitions at the Science and Technology Exhibition in the State of Querétaro (EXPOCYTEQ), focusing on interaction, multimedia usage and interest, as well as on the correlation between these variables. A different approach to the interest, interaction and interactivity levels is presented in terms of the body senses according to the type of exhibition analyzed. Also, some issues regarding interactive exhibitions are presented, and conclusions of multimedia and interactivity in cultural or scientific exhibitions are drawn, remarking the lack of modern human – computer interaction techniques such as interactive surfaces, virtual reality, augmented reality and brain – computer interfaces.

The paper is organized as follows. In Section 2, we describe the activities presented in EXPOCYTEQ as well as the qualitative observation and the considered interaction measures. In Section 3, we present the analysis of interaction-related variables. In Section 4, we present our conclusions, and in Section 5 the references are presented.

2 Experiment

The Science and Technology Exhibition (a.k.a. EXPOCYTEQ), an outdoor science exhibition, has occurred since 26 years as an effort to promote the social appropriation of STI at the state of Querétaro, México. The program includes conferences, workshops and exhibitions performed by professionals and researchers from more than 30 public and private institutes, companies and research centers.

Thirty exhibition modules were observed during several hours in the exhibition days, and data related to several aspects of the stand as well as to the behavior of the participants was recorded (a more extensive report was written and is included in the thesis work of the second author of this paper). The audience was almost entirely students from public elementary schools with some few from private institutions and some others from both public and private middle schools.

Observation, as many authors agree, is crucial in every research process [4]. In his paper, Morán states that observation is descriptive, analytical, and experimental, and very important when it is related to certain technologies. Some of the advantages of observation are the acquisition of real information and the perception of relevant behaviors. Thus, in the frame of information technology and its applications and the education trends and actions directed to achieve progress in STEM areas, the observation of EXPOCYTEQ gets a better comprehension of the involvement of students, organizations, research centers and the local government in these activities and the tools used to transmit what was intended.

2.1 Framework of Interaction Measures

We defined a framework of interaction measures which includes relevant measures that could influence the catch of the attention of the audience. These include colors, multimedia, interaction and interactivity. More specific variables are listed and described below.

- **Adaptability of content (AC).** Defined as the change of the content in presentation based on the visitor characteristics.
- **Adaptability of interaction (AI).** Defined as the change of the interaction in presentation based on the visitor characteristics.
- **Adaptability of transformation (AT).** Defined as the change of the station (module) based on the visitor characteristics. Content does not change.
- **Average Adaptability (AA).** A measure of the adaptation that takes into account the previous three adaptability measures. Obtained according to the equation 1.

$$AA = \frac{CA + IA + TA}{3} \quad . \qquad (1)$$

- **Accessibility (Acc).** Degree of participation at the station from the visitors.
- **Usability (Us).** Ease of use of the exhibition.
- **Robustness (RO).** Level of support to the station visitor. Related to the visitor's capacity to observe, to recover information and to adjust the task to him.
- **Ease of Learning (EL).** Ease of effective interaction to the station with new visitors.
- **Empirical Usability (EUs).** General level of usability based on actual perception.
- **Flexibility (FL).** Relative to the variety of possibilities the visitor and the station can exchange information.
- **Relative Usability (RUs).** Computed in terms of the robustness (RO), ease of learning (EL), ease of use (EU) and flexibility (FL), adapted from the conceptualization of usability given by the ISO 9126/0241. RUs is calculated with equation (2).

$$RUs = \frac{RO + EL + EU + FL}{4} \quad . \qquad (2)$$

- **General Interest (GITT).** General interest observed in the public.
- **Weighted Interest Average (WITT).**
- **General Interaction (GITX).** Rate of interaction with the visitors. High is better.
- **Weighted Interaction Average (WITX).**
- **General Interactivity (GITY).** Evaluation of capabilities of interaction of the station. High is better.
- **Weighted Interactivity Average (WITY).**

2.3 Weighted Measures for Body Senses

The Oklahoma Cooperative Extension Service of the University of Oklahoma [5] ranks the relevance of the five basic senses of the human body, and assigns them the weights specified in table 1.

Table 1. General relevance (GR) of the basic human body senses proposed by the University of Oklahoma and dominant relevance (DR) proposed according to the type of exhibition.

Sense	General Relevance (GR)	Dominant Relevance (DR)				
		A: VISUAL	B: AUDITORY	C: TACTILE	D: GUSTATORY	E: OLFACTORY
Sight	83%	40%	25%	25%	17.50%	17.50%
Hearing	11%	25%	40%	20%	7.50%	7.50%
Touch	3.50%	20%	20%	40%	15%	15%
Smell	1.50%	7.50%	7.50%	7.50%	20%	40%
Taste	1%	7.50%	7.50%	7.50%	40%	20%

We argue that the general relevance mentioned for each sense should be treated differently for more specific scenarios where the particular atmosphere predominating in the exhibition can have certain influence in the stimulated user's body senses. That is why we propose a new value (table 1 – dominant relevance (DR)) for the relevance of each body sense, according to the dominant sense of the correspondent stand. The proposed values for DR are empirically given by the authors according to what they consider the actual relevance of each sense in specific types of scenarios. One last variable, the Final Relevance (FR), for each sense is defined by equation 3.

$$FR = \frac{GR + DR}{2}\left(\frac{1}{100}\right) . \tag{3}$$

The weighted average of 5 elements whose respective weights add up 1 can be obtained with equation 4. Where x_i are the samples and a_i is the respective weight.

$$y = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 . \tag{4}$$

For weighted variables (WITT, WITX and WITY), the equation 4 is used with the FR values obtained using equation 3. In the equation 4 y is the WITT, WITX and WITY, respectively, the a_i's are the weights given as a FR for each body sense and the x_i's are the scores assigned to the interaction in the respective stand.

3 Analysis and Results

Observation of the organizations and institutions was documented in tables similar to the one shown in figure 1; from there, some useful conclusions were drawn. Figure 2 depicts one of the different activities carried out by the organizations. Figs. 3 – 5 show the computations of multimedia, adaptability, usability, interest and interaction measures of the observed stands. Fig. 4 (left) shows that multimedia was not very used in exhibitions. Interaction, interactivity, relative usability and average adaptability were not significantly high, either. In several cases these values were below the 50%, as was the case of adaptability and multimedia. As a consequence, the interest shown by the presents was not remarkable. For instance, in Fig. 4 (right) it can be seen that nearly half of the asked questions and from this portion only 13% asked in a more noticeable way; 50% was not interested in asking anything. The curves seem to have a constant value in every case, and whose individual values are not so distant from the mean, indicating that perceived status on each area for the stands is in general the same, with a few exceptions.

	STATIO	TOPIC	VISIT	VISIT Time	ATTENDEES	AGE	DURATION	General Interest (GITY)			General Interaction (GITX)			General Interactivity (GITY)		
8	ITESM	Nat. Sc	1	9h00	15	10	25	xQ	IQ	nQ	M	L	N	M	L	N
	Videog	Tech.		STYLE:	A, VISUAL				x			x			x	
	STAND CHARACTERISTICS				OBJECTIVES (%)			Stimulated Senses (%)			Stimulated Sens. (%)		WITX (%	Stimulated Sens. (%)		WITY (%
	SIZE	COLOR	MED	INTER	67-100	34-66	0-33	0.615	Sight	80	Sight	70	43.05	Sight	70	43.05
	3x3	60	60	6279				0.18	Hearing	80	Hearing	65	11.70	Hearing	70	12.60
	ADAPTABILITY				ACCESIBILITY			0.118	Touch	80	Touch	50	5.88	Touch	60	7.05
	CA	IA	TA	OTHER	Disability		Grade	0.045	Smell	1	Smell	1	0.05	Smell	1	0.05
	70	60	30	0	none		20	0.043	Taste	1	Taste	1	0.04	Taste	1	0.04
	USABILITY							↑	Others	1	Others	1	60.71	Others	1	62.79
	RO	EL	EU	FL	EUS	RUS	OTHER	WEIG HT	Interactive Parts	35	Interactive Parts	35	AVE	Interactive Parts	50	AVE
	60	45	50	40	50	48.8							37.40%			40.40%

Figure 1. Example of documented observations.

Figure 2. Some kids interact with a model in one of the exhibitions.

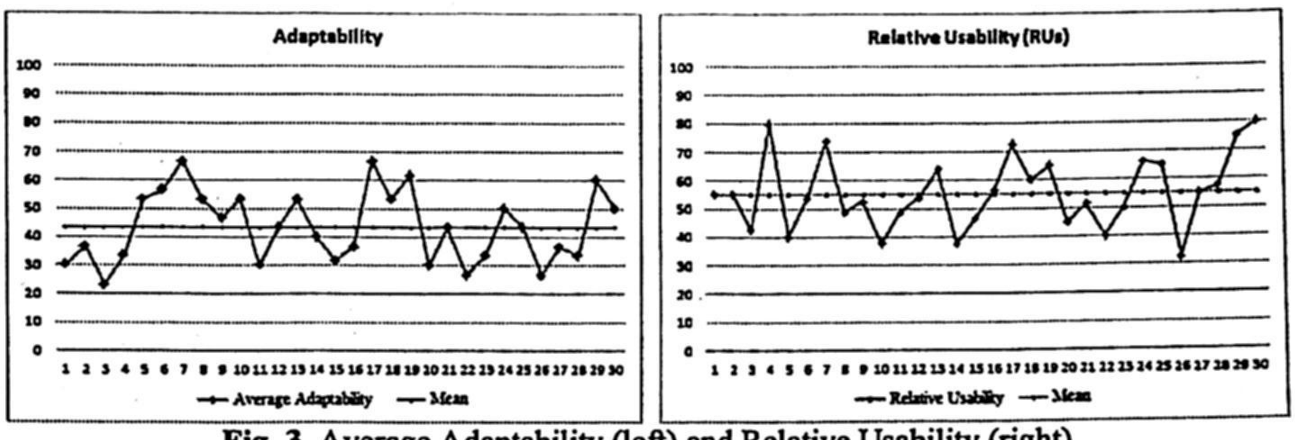

Fig. 3. Average Adaptability (left) and Relative Usability (right).

In figure 6 (right) we can see that multimedia, interest and interaction have similar paths along the x-axis, which means a close relation between these three concepts, and as multimedia can be easily included in an exhibition, it can be used more actively to generate interest and interaction.

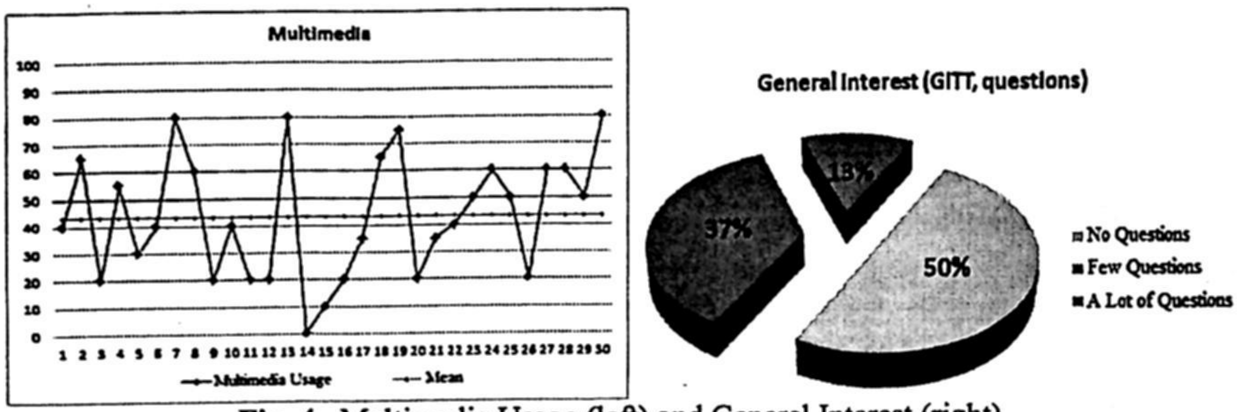

Fig. 4. Multimedia Usage (left) and General Interest (right).

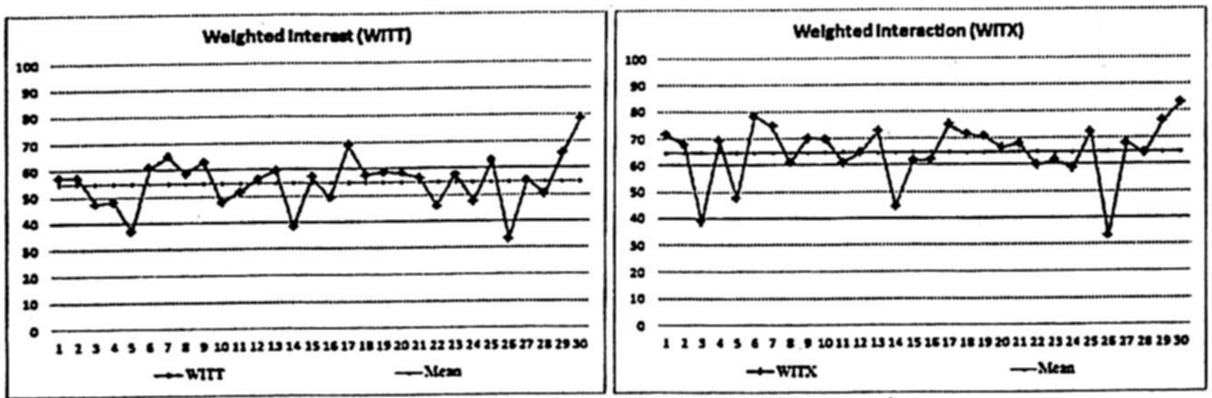

Fig. 5. Perceived weighted interest and interaction.

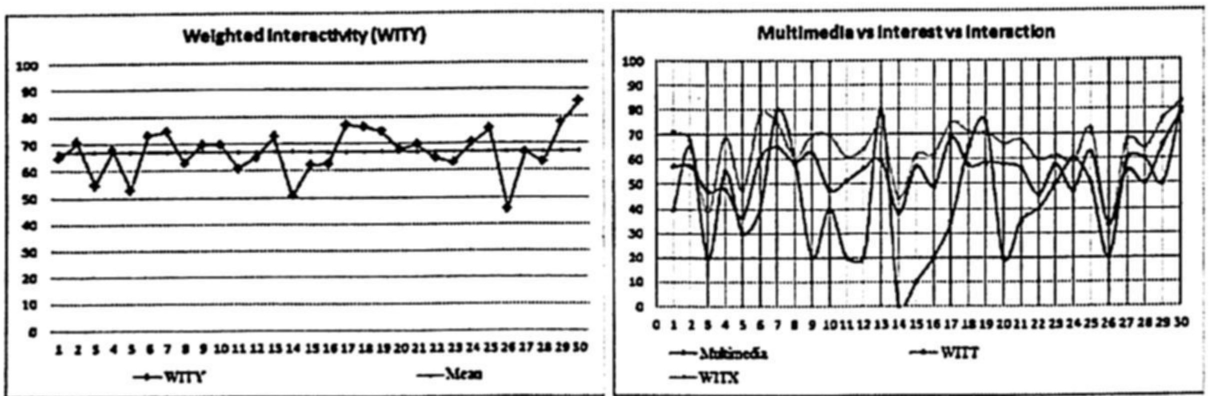

Fig. 6. Perceived interactivity (left) and comparison between Interaction, Interest and multimedia usage (right).

In figures 7 – 9 the correlation relation between interest and interaction and between adaptability, usability, interest and interaction in terms of multimedia is shown.

In the usability, interest and interaction vs. multimedia charts it can be seen that the best approximation for the existing relation is a straight line with a positive slope, suggesting a direct proportion between the variables; this is, the more multimedia is used in stands, the more adaptability (slightly), usability, interest and interaction.

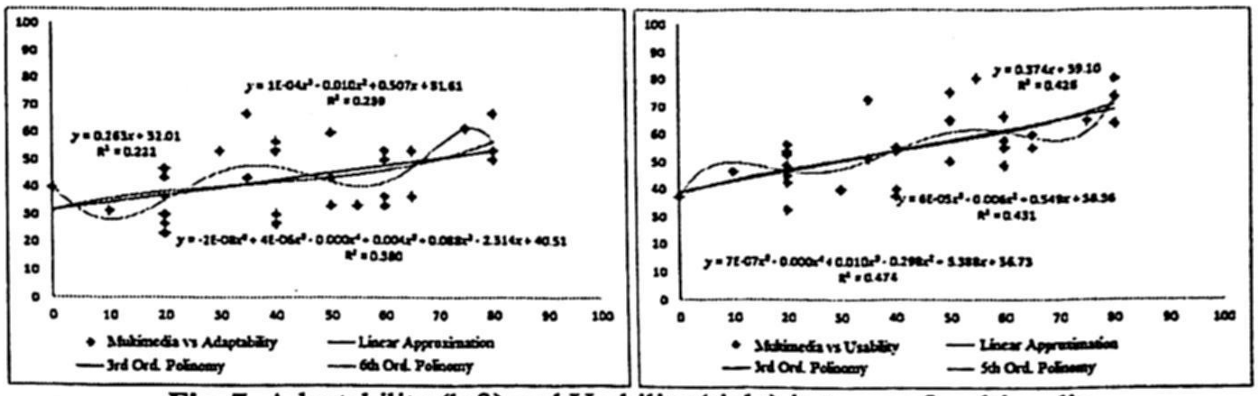

Fig. 7. Adaptability (left) and Usability (right) in terms of multimedia.

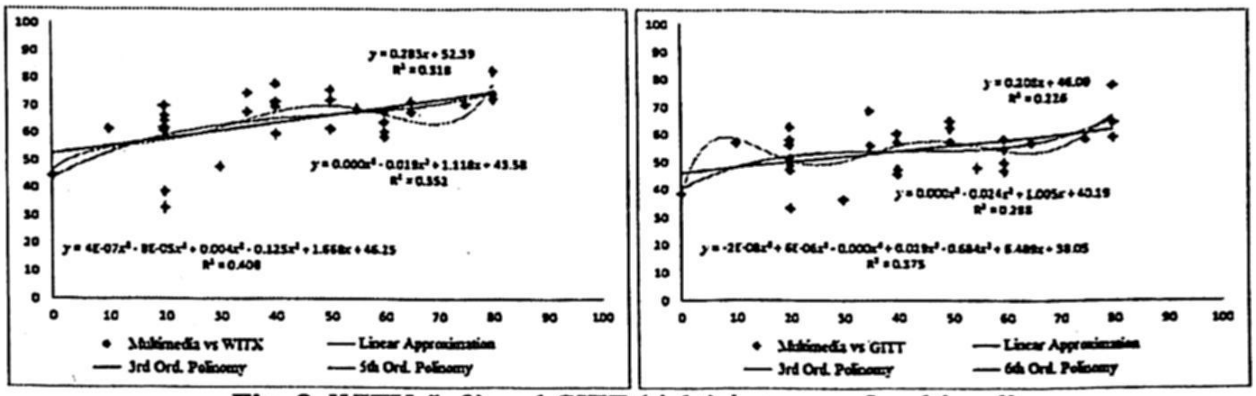

Fig. 8. WITX (left) and GITT (right) in terms of multimedia.

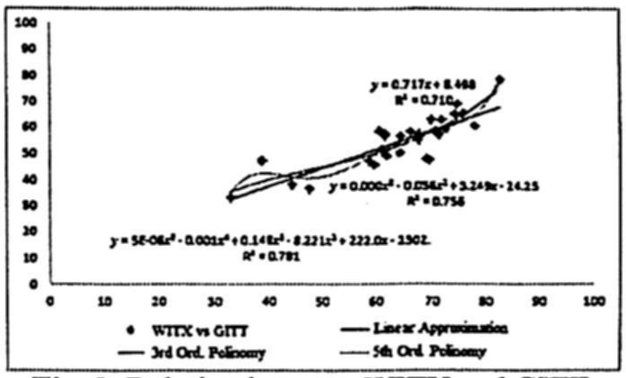

Fig. 9. Relation between WITX and GITT.

Although some other approximations are possible, the coefficients suggest again that the best approximation is a straight line. Fig. 9 shows that the almost 45° slope implies a growth almost identically in each of the curves. Fig. 8 confirms this, since the interaction and interest curves have practically the same shape. Also, the plots in Fig. 8 show that both interest and interaction are distributed in a very short range, meaning that in general there were not low levels of interest, though there is potential that can still be taken advantage of.

The observation study reveals that in general the attention of young and children is leaned towards STEM activities. There were no cases that required special attention on accessibility, and nothing was observed in the modules that took care of such cases, if any.

4 Conclusions and Future Work

Science, technology and innovation are essential components of the future at any country. This paper presents a first interaction analysis of outdoor science exhibitions; as a result it also encourages the use of novel technologies. It was shown that multimedia usage provides a better learning through improving the engagement of the audience and causing a higher level of interactivity and interaction. The use of multimedia is barely used in many STI expositions nowadays, despite the fact that this type of technology is more accessible day to day. Also, the lack of more advanced interactive devices such as multi-touch screens, interactive surfaces, and virtual and augmented reality was evident. A quantitative evaluation of the impact that modern HCI technologies in informal settings have in the K-12 students in their aspirations to pursue STEM-related careers is planned to be carried out in future EXPOCYTEQ events. The interactive system will include but will not be limited to head mounted displays, data gloves and brain computer interfaces.

We believe that any future Smart City concept will include the use of such interactive technology in urban environments. Actually, many Smart City demonstrations are using it. Observation is a primary task before automated vision algorithms can be implemented in Smart City contexts. This research will help to have foundations on designing future interactive technology for Smart City Learning concepts [8].

5 References

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