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ECOLOGY AT AN EXHIBITION: IMPACT AND INFORMAL LEARNING

CARME PRATS[1] & JORDI FLOS[2]

[1] Museo Nacional de Ciencias Naturales (CSIC). J. Gutiérrez Abascal, 2. 28006 Madrid. Spain.
[2] Department of Ecology. Faculty of Biology. University of Barcelona. Av. Diagonal, 645. 08028 Barcelona. Spain.

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SUMMARY

During 1986 and 1987, an itinerant exhibition on "Ecology" written by Professor Margalef was followed in eight cities in Catalonia, (NE Spain). An extensive survey was carried out that included a survey on visitors' opinions and an experimental study on learning. This paper studies the relationships between opinions on the different environments of the exhibition (in terms of "Like", "Dislike" and "Surprise"), the physical and formal contents of the environments, and the time spent by visitors in front of each. We also analyse the results of an experiment on learning applied to students from four different age levels who used the exhibition as a complement to their formal studies. The experiment evaluated the most liked and the most disliked topics in the exhibition. The factors studied which could have some effect on marks obtained in an examination were: a) seeing the exhibition; b) having prepared something on ecology at school before visiting the exhibition; c) receiving a general introduction on how to look at an exhibition, just before the visit.

The frequency of positive opinions on a given environment is inversely related to its density of information and directly related to the time spent looking at it. Students using the exhibition as a complement to their formal education only benefit if they like the exhibition (studied environment by environment). Having prepared something on ecology at school before visiting the exhibition has striking effects on teacher trainees, which raises serious questions about the way formal teaching is often carried out.

KEY WORDS: Natural history, museum, exhibition, survey, learning, ecology.

INTRODUCTION

Science is an important part of culture, and as such has to be made available in a comprehensible form. This consideration makes it possible for two traditionally separate groups, the scientific community and the general public, to draw a little closer to each other.

The use of exhibitions as a vehicle for communication has grown in recent years. The value of exhibitions as an effective method of information and introducing new products or ideas is beyond doubt. The design of an exhibition allows the combination of a wide variety of market techniques, both in terms of presentation (graphic design, audiovisual systems and incorporation of three dimensional objects), and the possibility of provoking passive or participatory behaviour on the part of the visitor, in the use or otherwise of interactive programmes.

If this range of aesthetic and participatory possibilities make the exhibition an ideal means of communication, they also involve a number of instrumental restrictions, which have to

be taken into account as they arise. An exhibition is like a theatre without actors, with the plot and performance of the piece lying in the scenic arrangement itself.

Traditional natural science museums have evolved to the point where they currently try to incorporate a didactic discourse (both precise and comprehensible) in their exhibitions. The objects on display (species and models) are not only offered as *objets d'art*, but form part of a more elaborate message; consequently the need arises to evaluate the exhibitions. It is necessary to know to what extent the intended message of the exhibition's initial concept has been communicated. Therefore, there are two clearly defined fields of research in natural science museums, which correspond to the two functional environments of the present day museum: 1) The museum's scientific research, which corresponds to its traditional functions (collecting, preserving and researching), which contribute to the documentary base and scientific updating which are indispensable to the museum; 2) Research into the "educational objective", which includes the whole body of public exhibitions and activities that stem from them, their collections, subject matter and the research activities of the museum departments. It corresponds to the function of the public projection of the museum (scientific communication) and contributes the empirical base in the understanding between the museum and its public.

This study links up with a line of museographical research (evaluation of exhibitions in Natural History, Science and Technology museums and zoos), mostly developed in the United States and Canada, but also in the United Kingdom, with other connotations (LUCAS, 1983; SCREEVEN, 1984).

Research studies in museums are normally structured around a series of questions, and use similar methods and evaluation resources that basically follow two patterns: direct observation and analysis of the verbal or written replies of the visitors.

Visitor surveys set out to discover the kind of public, and their motivations, interests and preferences (ELLIOTT & LOOMIS, 1975). When direct observation is used, information is obtained concerning the amount of time spent in the different sections of the exhibition, the behaviour and different itineraries followed by different kinds of visitors (CONRAN, 1977; SCREEVEN, 1976; FALK, 1982; McMANNUS, 1987; PEARL & KOOL, 1988). This information, while not giving direct indications related to learning, characterises the conditions in which this may occur.

The most complex objective is the evaluation of learning from a specific exhibition. This involves a stringent experiment design and the development of accurate measuring methods. Many studies, above all in American centres, have been carried out to measure the effect of different experimental conditions on the learning and motivation of schoolchildren (STONEBERG, 1981; GENNARO, 1981; TANCK, 1982; KORAN *et al.*, 1983; LEHMAN & LEHMAN, 1984; FLEXER & BORUN, 1984; PRATS & FLOS, 1984), as well as on behaviour and learning linked to interaction units (EASON & LINN, 1976; ARTH & CLAREMAN, 1977) and a number of experimental studies on learning on field excursions comparing different environments (FALK *et al.*, 1978; FALK, 1983; PRATS, 1985).

This paper contains results obtained from a research project (PRATS, 1990) based on the "Ecology" exhibition prepared by Professor Ramon Margalef for the Barcelona Country Council (MARGALEF, 1985). In creating and developing the exhibition, the author used the language of display as a didactic discourse to explain certain features of his own speciality, ecology.

There are three qualities which make the author particularly suited to the

development of this exhibition: 1) His extensive knowledge of the subject; 2) An ability to select a line of argument which is not excessively simple and which is carefully defined in its general content and in each of its parts; 3) The imagination to translate concepts into examples from daily life which are rarely associated with ecology.

The characteristics of the author and the effort of the designers to provide the correct physical presentation for the theoretical discourse together produced the ideal study material from the point of view of scientific communication.

Here we present the opinions of the exhibition given by the visitors and their relationship with the physical characteristics of the exhibition and time spent in the visit. We also present the results of the study on learning about two of the eight topics that were developed in the exhibition and which received the best and worst opinions from the visitors.

It is hoped that information will be obtained from these studies which will lead to an improvement in exhibitions, making them more attractive while at the same time faithfully communicating the message that the author of the exhibition wishes to transmit. The next step will be to make potentially unattractive contents enjoyable for the public, rather than to increase the number of well-accepted elements in order to obtain easy success. Natural Science exhibitions should attract a wide public who will come to know and share an essential aspect of the culture of our time and acquire an overall, up-to-date vision of the world we live in.

MATERIAL AND METHODS

THE EXHIBITION

The Ecology exhibition consists of an introduction and 92 elements divided into eight highly differentiated parts, to which we shall refer as the eight environments of the exhibition: 1. The blue planet; 2. Energy and production; 3. Richness and variety of life; 4. The selection game; 5.The language of nature; 6. The rhythm of life; 7. An old setting: the forest; 8. An important actor: man. This ordering suggests an itinerary, although each environment can be read independently on its own merits.

The exhibition was planned to be itinerant. For this reason its basic design centred around simple, mobile metallic structures that allowed for a spatial rearrangement depending on the characteristics and dimensions of each place where it was put on show (Figs. 1 and 2). The visual impact is obtained essentially through large, high-quality photographs and full colour drawings. There are also elements that can be manipulated (games, maquettes) and three-dimensional models.

The contents are slightly removed from what is commonly understood as "ecology", although they set out to reflect this science in the events and phenomena of everyday life. Nevertheless, the exhibition contains a lot of information, often on a highly scientific level. In the general text the author selected fragments that were coloured on the exhibition panels in order to enhance and emphasize certain concrete ideas. There is complementary material in the form of a triptych and a book-catalogue (MARGALEF, 1985). A thorough description of each environment's contents is given in PRATS *et al.* (1989) and PRATS (1990).

In order to objectify the characteristics and conditions of each environment, we have taken into account the following descriptors (Table I): the number and dimensions of the panels that constitute each unit or environment; the number and dimensions of the photographs and drawings of each panel; the words and lines of text of each element, whether panel or illustration; the words and lines of text

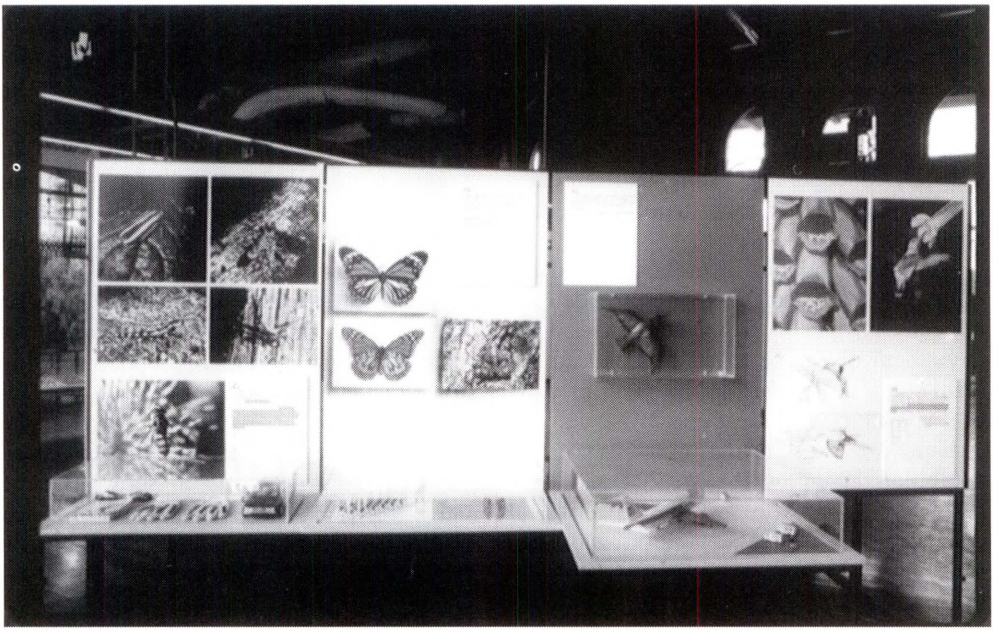

FIGURE 1. A view of Environment 4, "The selection game", at the Museu de Zoologia (Barcelona) venue.

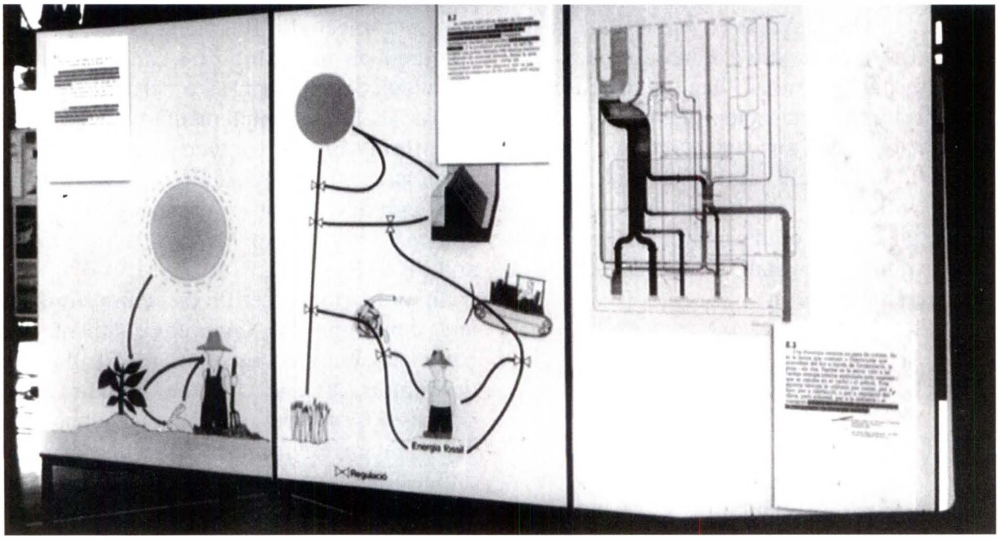

FIGURE 2. A view of Environment 8, "An important actor: man", at the same location.

TABLE I. Features of the exhibition environments. Panels, total number of panels forming each environment; Illus., number of photographs and drawings illustrating each part; Text, number of lines of text per total number of panels in each environment; Und., number of lines underlined in the total number of panels in each part; Mod., number of three-dimensional elements in the whole environment; Man., number of manipulable elements; Gam., number of games contained in each part of the exhibition; Vid., number of videos.

	Panels	Illus.	Text	Und.	Mod.	Man.	Gam.	Vid.
A1	10	37	58	16	-	-	-	1
A2	9	16	77	20	1	2	-	-
A3	7	12	69	13	-	1	-	-
A4	14	54	143	28	4	6	1	-
A5	7	15	70	15	2	1	-	-
A6	11	29	140	37	1	3	1	-
A7	9	41	105	15	3	2	1	-
A8	10	18	124	41	1	-	-	1

underlined (that is, a measure of the density of information) and the number of maquettes or models, manipulable elements, videos and games contained in each environment.

The exhibition travelled to eight different Catalan cities (Fig. 3). Although the specific characteristics of each place must be taken into account when some results are analysed (PRATS *et al.*, 1989), the results and conclusions presented in this paper are independent of the particular spatial layouts of the different cities.

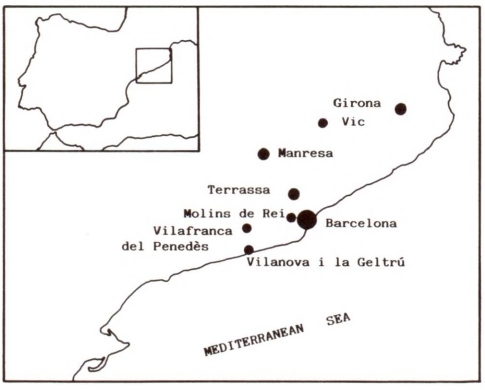

FIGURE 3. Situation of the eight Catalan cities to which the exhibition travelled. Number of inhabitants (1986 data) are given in brackets: Barcelona (1,701,812); Terrassa (156,458); Manresa (143,615); Vilanova i la Geltrú (45,039); Vic (28,399); Vilafranca del Penedès (26,433) and Molins de Rei (18,160).

OVERALL STUDY

QUESTIONNAIRES ON OPINION

Opinions were collected from a written questionnaire that visitors to the exhibition were invited to complete, and which consisted of both "open" and "closed" questions. Thus the results presented here correspond to the voluntary collaboration of a sector of the public that freely chose to register their opinions and suggestions. In the questionnaire, closed questions were used to obtain demographic information, while opinions and interests of visitors were obtained from the open questions, replies to which were subsequently analysed: What did you like/dislike/find surprising about the exhibition? Why?

Being conscious of the problems that can arise in the use of opinion study surveys (SCHUMAN & SCOTT, 1987), we decided not to use the direct interview method, thus avoiding lively and variable interference from the researcher, and prepared the questionnaire very carefully (PRATS *et al*, 1989; PRATS, 1990). The limited range of application of the questions, and the nuances of meaning obtained from the questions asking for reasons for the different opinions, facilitated the interpretation of replies. Furthermore, this opinion sounding project was complemented by an analysis of the itineraries followed by visitors to the exhibition, which was then related to the replies to the written questionnaire. Data concerning visitors' conduct and itineraries were obtained through direct observation of their movements and through timing them as they went from one environment to the next. These data were related to the demographic characteristics of the visitors observed. A very extensive experiment on

learning was also conducted. We will consider the results of those items with relevance from the point of view of the opinions. The learning data were related to the opinions and behaviour data.

The written questionnaires have been published elsewhere (PRATS *et al.*, 1989). Here we use only some of the demographic data and the opinion replies to the question about like, dislike and surprise.

Having collected the questionnaire in all the cities to which the exhibition travelled, one of the most laborious tasks was to create a code that would allow the most objective possible transcription of the replies. This numerical transcription presented no problems in the case of the closed questions, in which the reply is chosen from a set of pre-established alternatives. On the other hand, the open questions, in which replies are developed freely, required a more elaborate process. The mathematical analysis of the codified replies was carried out by means of the SPSSx statistical package at the Calculation Centre of the University of Barcelona.

The code was very stringently applied. To start with, it was ratified and adjusted by four biologists who formed part of the study team, first individually and then together. Then, each questionnaire was corrected by two different people while a third (the same for all the questionnaires) revised and unified the definitive results of the whole survey. A total of 2,218 questionnaires were analysed.

OBSERVATION OF VISITORS' ROUTES

The routes followed by 296 individuals were observed and recorded by discreetly following them while they visited the exhibition. Their movements and their itineraries were recorded on a plan of the venue which featured a detailed layout of the Ecology exhibition.

Besides the time spent in each place, indicating what activity was being carried out, demographical information about the visitor was also given (sex and age group) as well as the social composition of the visit ("who they came with").

DESIGN OF LEARNING EXPERIMENT

The experiment was carried out with a total of 1,580 students in 161 groups from 28 different schools and colleges in Catalonia. Four different students levels were worked with, which were from the eighth year of EGB (13, 14 years old), the first year of BUP (14, 15), COU (18, 19) and teachers trainees (20 to 35 years old). None of the groups was specifically chosen for the experiment; once the teachers had requested a visit their collaboration was then asked for. The number of students in each level therefore represents the use made of the centre by each group.

The students participating in the exhibition were from particularly important levels within what is considered to be the most frequent route through formal education.

- The eight year of EGB is the last year of the second stage, in which all students study the same subjects. At the end of this year students have to make a choice between going on to study sciences or arts, or leaving to enrol in a course of professional training. The sample from this group included 220 students.

- The first year of BUP is the course which follows on from EGB, and represents, with age differences of between six months and a year, a group in their first year of specialisation in science. This level provided the most visitors to the exhibition and shows that the teachers regularly used it as a teaching aid. 945 students from this level took part in the experiment.

- Students of COU, from the science speciality, were the second largest group for whom the exhibition was appropriate to their study programme. Bearing in mind that this student population is much smaller and that there are fewer students in each centre, it is also a level which regularly

used the exhibition as a complement to the natural science study programme. The sample included 238 students.

- The teacher trainees were also interesting to evaluate, as they had already decided to work in education, this field being one of the fundamental objectives of the exhibition. This group contained 177 students.

The main factor that we wanted to look at was the visit to the exhibition itself (a two-level factor), but we also wanted to take two other factors into account. The first was having prepared or studied something about ecology before attending the exhibition (two-level factor), and a second, which applied to the experimental groups who saw the exhibition, was receiving a brief introduction to museums before visiting the exhibition.

Samples were taken by making three random subgroups within each class group as they entered the museum. Each group was subjected to different experimental conditions (yellows, greens, reds, from Table II). The extent of their knowledge of ecology was measured by a questionnaire on concepts included in the exhibition. These questionnaires also contained the questions from the opinion survey addressed to voluntary visitors.

A pilot questionnaire was prepared and applied to six groups of between 35 and 40 students from four different schools at BUP level, and the answers used to make up the definitive questionnaire in three different formats. The pilot questionnaire enabled us to see whether the students had understood the questions, and from the content of the answers we could see if the questions were sufficient to reveal differences in the knowledge of students from the same level. The ease with which subjects understand the questions index (easibility index) is fundamental in evaluating knowledge (PRATS, 1985). Both those questions which nobody answers and those which everybody answers are useless in providing an evaluation of differences in individual knowledge.

TABLE II. Experiment on learning design scheme. See text.

	Introduction to museums	Subject preparation	
		NO	YES
Seeing the exhibition	NO	Yellows NP	Yellows P
	YES	Greens NP	Greens P
		Reds NP	Reds P

By using the same questionnaire and the same marking scale for all levels of students, it was possible to contrast the answers within each level and observe the progression from one level to another (PRATS, 1989).

RESULTS AND DISCUSSION

IMPACT OF THE EXHIBITION

On the whole, the exhibition met with approval, since 89% said that they had enjoyed it and intended either to return or recommend it to friends. 40% of the visitors considered it suitable for everyone. The remainder of replies are divided up into a number of smaller percentages, with the exception of those who said that it was also ideal for students: 21%.

The data collected on opinion is presented in figures 4 and 5, in two sets: the whole voluntary population (eight cities taken together) and the students who participated in the learning experiment. This paper does not consider aspects outside the environments that the answers to the questionnaire also touched on (PRATS *et al.*, 1989). The most important tendencies of opinions of the eight items were similar for all the cities to which the exhibition travelled. There are two generalizable opinions, which referred to: "The selection game" (Environment 4) and "An important actor: man" (Environment 8).

"The selection game" (Environment 4) was widely liked, was found surprising to a lesser degree, and very few expressed dislike. Therefore, this exhibit was the most succesful, according to those who completed the questionnaire.

"An important actor: man" (Environment 8) was the opposite case, since no one mentioned having either liked or having been surprised by it; on the contrary, those that did mention it at all said that they had disliked it.

Considering other parts of the exhibition, "An old setting: the forest" (Environment 7) is the part of the exhibition most mentioned after Environment 4. Environments 2, 3, 5, and 6 were mentioned very little, while Environment 1 was mentioned with slight variations in reply, depending on the city.

REASONS FOR LIKE, SURPRISE AND DISLIKE

Each question concerning opinion was accompanied by another asking why the person had mentioned like, surprise or dislike regarding the exhibit. The scope of visitors was an interesting interpretation of the communication power of the exhibition as grasped by the public.

"The selection game" (Environment 4) can be considered, on the basis of the reasons given, an exhibit that was liked and which caused surprise because it is attractive and interesting, with a content that is easy to understand and that people did not expect to find. It also has an outstanding participative quality compared to the other aspects mentioned, which allowed the visitor to experiment. The participative element corresponds to the birdsong game, which is the part of the exhibition most mentioned in this environment.

"An old setting: the forest" (Environment 7) was also considered to be an attractive, well-presented part that, while not surprising, was liked by virtue of its didactic content. The most important reasons mentioned for this were that it is a subject people should know about and also that it is closely linked to nature and the present day. This way of showing nature was the aspect people found most surprising about this particular environment. On the other hand, no one mentioned its participative possibilities, even though objectively it was the section that contained most, with a game and an apparatus that could be manipulated to show slides of animals. It was this apparatus, however, that people mentioned as having liked most about this particular environment.

"An important actor: man" (Environment 8) was the only part of the exhibition which produced only unfavourable comments. Criticism was levelled above all at the presentation, which was found to be unattractive and boring, and at the subject itself or some of the aspects dealt with. It was specified that there was no mention of the deterioration of the ecosystem and there were even those who considered the subject as having nothing to do with ecology. Another important reason why it was disliked was that people found it difficult to understand and unclearly expressed.

We think that the author himself expressed a simpler message in Environments 4 and 7 than in Environment 8. "The selection game" and "An important actor: man" included some ideas that were new for many people, but the former Environment was better put together, with very adequate examples.

ENVIRONMENTS, IMPACT AND DESCRIPTORS

This section relates the formal characteristics of the exhibition's eight parts or environments (dimensions, texts, illustrations, etc.) to the opinions received. These have been transformed into probabilities: 1) PO: probability of giving an opinion on a given environment; 2) PL: probability of liking conditioned to giving

TABLE III. Descriptors of the environments that enter as independent variables in a step by step multiple regression (significance $p < 0.05$), where the dependent variable is that indicated on top: PO, probability of giving an opinion; PL, probablity of liking provided an opinion is given; PD, probability of disliking provided an opinion is given. The descriptors used are given in Table I. The sign + or - preceding the name of the descriptor means a positive or negative effect. A dashed line means that no variable was significant.

	Variables					
		PO		PL		PD
total population	+SIZE	-UNDERL	+PHOTOS	+MANIP	-UNDERL	-MANIP
AGE 1	+ SIZE		+PHOTOS	+MANIP	-MANIP	-PHOTOS
AGE 2	+SIZE	-UNDERL	+GAMES		-MODELS	-MANIP
AGE 3	+PHOTOS		----------	----------	-MODELS	+TEXT
AGE 4	-UNDERL		----------	----------	----------	----------

an opinion; 3) PD: probability of disliking conditioned to giving an opinion.

To study the dependence between the probabilities of giving an opinion and the physical characteristics of the parts, a step by step multiple regression was carried out in which the independent variables were those of Table I, and the dependent variables the different probabilities.

Table III shows, by a sign followed by the name of the variable, those variables that enter in the regression, being introduced when they have a significance above 0.05 (standard method). It can be seen that the probability of giving an opinion is directly proportional to the size and inversely proportional to the density of information. The probability of giving a "like" opinion (having given an opinion), is proportional to the quantity of illustrations, manipulable elements and games for the two youngest groups, while for the other groups there is no significant dependence. For the probability of giving a negative opinion, and taking the respondents as a whole, the only two variables that affect the regression are the density of information and the manipulable elements, but if it is done according to age groups, the probability of giving a "dislike" opinion is inversely proportional to the density of illustrations, manipulable elements and models, and directly proportional to the quantity of text.

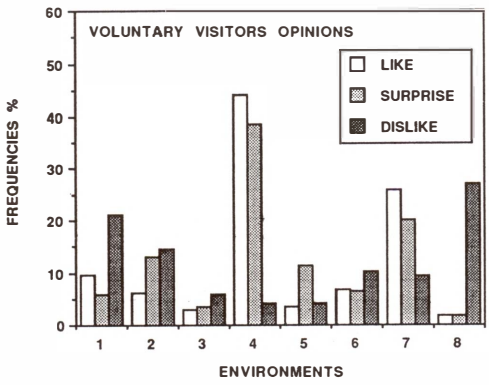

FIGURE 4. Frequencies of replies (like, surprise, dislike) of voluntary visitors for the eight environments of the "Ecology" exhibition. Percentages were calculated for each kind of reply, through the eight environments, for the whole population from the eight cities where the exhibition travelled.

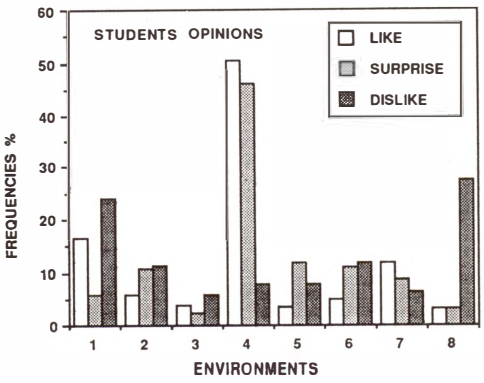

FIGURE 5. Frequencies of replies (like, surprise, dislike) of students participating in the learning experiment (the experiment was carried out in Barcelona).

We also calculated the partial correlations between the probabilities and the descriptive variables, controlled by the size of the environment and the number of photos; the importance of the density of information (underlined text), of manipulable elements and of the three dimensional models when qualifying an opinion is confirmed. It is interesting to note that the older visitors did not qualify their opinions in relation to the descriptors analysed and that the probability of giving an opinion is closely associated (inverse relationship) with the density of information. This is probably due to the older visitors being more accustomed to giving positive opinions, or rather, they tend to give an opinion only if they do not have to give the "dislike" opinion.

Another interesting observation is that the three dimensional models are more important for adults or older students (Classes 2 and 3) while the opinions of the youngest students were more closely tied to the presence of manipulable elements, games and illustrations.

There is, therefore, no such thing as an ideal exhibit, given that this prototype will depend on the content, will be different according to each exhibition and will probably also depend on the characteristics of each museum and even of each visitor. It is clear that the most attractive exhibits are those with a short and clear message, vividly displayed (ALT & SHAW, 1984).

TIME SPENT ON THE VISIT AND OPINION

A museum visit normally lasts no longer than two hours (FALK, 1982). No more than thirty minutes of this time is dedicated to the exhibition itself, with the rest of the time spent walking, in the shop, the cafeteria or the toilet. As regards observation of each exhibit, the maximum average time spent is thirty to forty seconds. The visitors that we observed in this study dedicated between 24 and 31.5 minutes to the exhibition, distributed in an inverse order to their respective ages. The average time spent on each particular exhibit was between 10 and 30 seconds.

One would expect that the probability of an opinion being expressed about an environment to be in direct proportion to the time spent looking at it. It is to be expected too that if visitors spend a long time in front of a panel or in an environment, it is because they like it. It can be considered that "like" and "surprise"

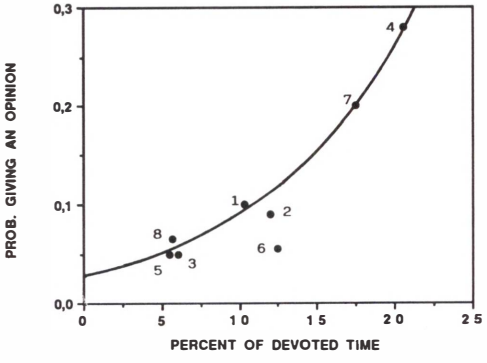

FIGURE 6. Dispersion diagram for the probability of giving an opinion versus the percent of time devoted to this environment. An exponential curve was fitted to the data (R^2=0.97) to show the general trend without including Environment 6 (see text for an explanation).

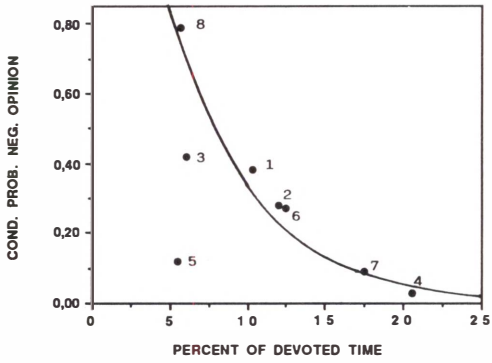

FIGURE 7. Dispersion diagram for the probability of expressing a negative opinion on an environment, conditionned to having expressed an opinion on that environment, versus the percent of time devoted to it. An exponential curve was fitted to the data (R^2=0.92) to show the general trend without including Environment 5 (see text for an explanation).

opinions are positive, while "dislike" is clearly negative. An analysis of the probability of negative opinions being expressed about an environment in relation to the time spent in front of it is the equivalent of an analysis of positive opinions (like and surprise) taken together. As regards the time spent in seeing the exhibition, we considered that to make comparable the different itineraries and behaviour patterns of the different classes of age and sex, as well as to understand that subjective time is what is in fact related to the kind of opinion, we have used the percentage of the total time of the itinerary devoted to each environment as our reference variable.

We have calculated for each of the environments (1 to 8) the probability of an opinion being expressed and the probability that such an opinion, if expressed, will be negative (figures 6 and 7). The data clearly show that there is a direct link between the percentage of time devoted and the expressing of an opinion. In figure 4 we have drawn an exponential curve that was fitted to the data after taking out Environment 6, as it was seen that it may be considered an exception that needs to be examined. This section was very attractive since it contained a game called the "tree-trunk game", a magnifying glass through which to see growth rings in the section of a trunk and also a number of metrometers associated with the rhythms of different animals. Although considerable time was devoted to this section, since otherwise it could not be properly exploited, people did not express opinions in the proportion to which one might expect on the basis of the time devoted to it. On the other hand, if the visitor expressed an opinion, this was negative in a proportion similar to what one would expect from the time spent (Fig. 7).

As regards negative opinions, the probability of an opinion expressed being negative falls as the time devoted to an environment increases, following the same exponential trend (but with a negative slope). The exception to the general tendency is Environment 5 (which was excluded from data used to fit the curve in figure 7). This section contained a water wheel made of Meccano, but it was a very small environment. People in general did not spend much time there, but it was unnecessary to do so in order to see it and the probability of opinions being expressed about this environment follows the overall tendency. The environment was liked, even though it did not attract much attention.

We can conclude that the relative time

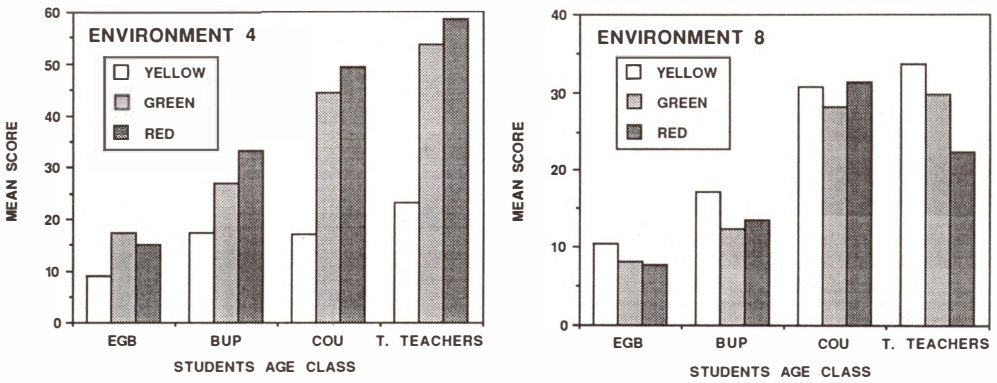

FIGURE 8. Distribution of the average scores of knowledge of Environment 4 (left) and Environment 8 (right), for each level of students and experimental subgroup (Yellows answered the questions before seeing the exhibition; Greens after seeing the exhibition and Reds received an introduction to museums, saw the exhibition and took the test).

Table IV. Number of individuals (n), mean score (m) and its standard deviation (st.dev.) obtained for the different levels of students (EGB, BUP, COU and Teachers trainees; see text) and experimental conditions, on Environments 4 and 8. Yellows answered the questions before seeing the exhibition; Greens after seeing the exhibition; Reds received an introduction to museums, saw the exhibition and took the test.

		ENVIRONMENT 4				ENVIRONMENT 8			
		EGB	BUP	COU	Teach. T.	EGB	BUP	COU	Teach. T.
	n	59	101	53	43	59	101	53	43
Yellows	m	9	17.4	17.2	23.3	10.4	17.2	30.8	33.6
	st dev.	13.5	13.8	15.6	18	13	14.5	14.9	18.4
	n	54	90	51	31	54	90	51	31
Greens	m	17.5	27.1	44.3	53.5	8.2	12.3	28.2	29.7
	st dev.	17.9	18.7	21	22.6	12.4	11.1	22	17.7
	n	49	99	56	42	49	99	56	42
Reds	m	15.1	33.3	49.3	58.6	7.8	13.6	31.3	22.4
	st dev.	16.1	20.5	25.3	24.8	11.3	16.4	24.8	18.2
Global Mean score		13.9	25.9	36.9	45.1	8.8	14.4	30.1	28.6

devoted to an environment is a clear indication that it was liked only when the proportion is higher than about 13% of the total time spent at the exhibition. This level of 13% is probably not independent of the size of the exhibition as we can note that a uniform distribution of time among the eight environments would give a 12.5 % of time devoted to each one of them.

Some subjective relationship must exist between the time devoted and the benefit gained (psychological, cultural, enjoy, etc.). This balance, which is difficult to set up *a priori,* is what we should attempt to achieve in exhibitions.

LEARNING OF EXPERIMENT GROUPS

We decided to study the acquisition of knowledge, or the amount learnt from the exhibition, using those two items for which the opinion and observation have produced opposite results: better for Environment 4 and worse for Environment 8, and with the same trends shown by all the visitors and students subject to the experiment.

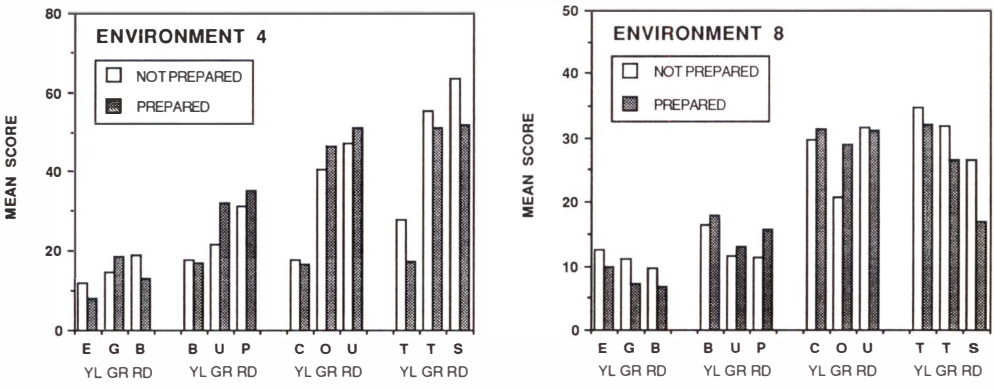

FIGURE 9. Distribution of the average scores of knowledge of Environments 4 (left) and 8 (right), for each level of students and experimental subgroup, for those who had prepared or not something on ecology at the school before the visit to the exhibition (Prepared and not prepared). At the bottom, YL, yellows; GR, Greens; RD, Reds (see also figure 6 and text).

TABLE V. Number of individuals (n), mean score (m) and its standard deviation (st.dev.) obtained for the different levels of students (EGB, BUP, COU and Teachers trainees; see text) and experimental conditions on Environments 4 and 8. See Table IV. Prep.= groups of students who had prepared something on ecology at school before the visit; Not Pr.= students who had not prepared anything on ecology before the visit.

			ENVIRONMENT 4				ENVIRONMENT 8		
		EGB	BUP	COU	Teach.T .	EGB	BUP	COU	Teach.T.
		n 14	47	19	24	14	47	19	24
	Not Pr.	mean 11.8	17.8	17.9	27.9	12.5	16.4	29.7	34.8
		st.dev. 13	14.1	18.7	20.2	12.8	11.3	15	17.7
Yellows									
		n 45	54	34	19	45	54	34	19
	Prep.	mean 8.1	17	16.8	17.4	9.8	17.9	31.5	32.1
		st.dev. 13.7	13.6	14	12.9	13.2	16.8	15.1	19.5
		n 13	43	17	18	13	43	17	18
	Not Pr.	mean 14.6	21.7	40.6	55.3	11.2	11.5	20.8	31.9
		st.dev. 15.6	16.2	19.9	22.5	16	10.7	23	13.4
Greens									
		n 41	47	34	13	41	47	34	13
	Prep.	mean 18.4	32	46.2	51.2	7.3	13.1	29	26.5
		st.dev. 18.6	19.6	21.6	23.6	11.1	11.6	21.8	22.6
		n 16	47	23	24	16	47	23	24
	Not Pr.	mean 18.8	31.3	47	63.5	9.7	11.3	31.7	26.5
		st.dev. 17.7	20.2	21.8	27.8	9.7	14.6	21.6	18.7
Reds									
		n 33	52	33	18	33	52	33	18
	Prep.	mean 13.3	35.1	50.9	51.9	6.8	15.8	31.1	16.9
		st.dev. 15.2	20.8	27.7	19	12	17.7	27.2	16.3
Global Mean									
	Not Pr.	15.1	23.6	35.2	48.9	11.1	13.1	27.4	31.1
	Prep.	13.3	28	38	40.2	8	15.6	30.5	25.2

Figures 8 and 9 show the distribution of the average scores of knowledge of Environments 4 and 8 respectively, for each level of students and experimental subgroup (Yellows answered the questions before seeing the exhibition; Greens after seeing the exhibition and Reds received an introduction to museums, saw the exhibition and took a test). Tables IV and V show means and standard deviations of each group.

SIGNIFICANCE OF THE KNOWLEDGE SCORES

An analysis of the variance (ANOVA) was carried out for each of the knowledge measurements in order to assess the significance of the mean differences observed among the different experimental conditions. The tables of the ANOVAs are not shown, but the significant differences will be commented upon, along with those cases in which interactions amongst factors were also significant. Although we have taken a probability of 0.05 as a norm for the significance limit of the Statistic F, in most cases in which the differences are indicated as significant, the probability of the Statistic F are much less. In any case, there is no important conclusion based on differences that have dubious significance levels.

In the first ANOVA two factors were

considered: a) seeing the exhibition and b) preparing something on ecology at school. The second ANOVA performed was for those who had seen the exhibition and considers the effect of receiving an introduction to museums.

The trends for the scores for each item and level are shown in Table VI, with an asterisk indicating those which have a probability for F of less than 0.05. The signs + and - indicate that the score increases or decreases.

In EGB the only significant tendency is having seen Environment 4 of the exhibition. Those students who saw this area received higher marks than those who answered the questionnaire before seeing the exhibition.

BUP appeared to be the group which was most receptive to all the factors analysed. For Environment 4 it is significantly positive as those who have seen the exhibition, those who have done some preparation, and within the group that has seen the exhibition, those who received the introduction, receive higher knowledge scores. As regards Environment 8 they are also receptive to the exhibition, but in a negative sense. There are higher marks for before the exhibition than after. To interpret the diminishing knowledge scores, it is necessary to bear in mind that students of BUP respond less to the part of the questionnaire referring to Environment 8 after seeing the exhibition. It may be that the answers have not worsened with respect to those who have not seen the exhibition, but that they have been more selective in answering and have chosen questions that do not correspond to the subject matter of Environment 8.

As regards COU, only the improvement of scores for Environment 4 after seeing the exhibition is significant.

The teacher training students, as with all other levels evaluated, answered the item 4 questions significantly better after having seen the exhibition. Unlike the other levels, previous preparation has a negative effect

TABLE VI. Asterisks indicate scores which have a probability for F of less than 0.05. The signs + and - indicate that the score increases or decreases.

Students level	EGB		BUP		COU		Teacher trainees	
Environment	A4	A8	A4	A8	A4	A8	A4	A8
Seeing the exhibition	*+	-	*+	*-	*+	-	*+	*-
Preparation	-	-	*+	+	+	+	*-	-
Introduction	-	-	*+	+	+	+	+	-

for both Environments 4 and 8. Those students who have received some ecology preparation therefore receive lower knowledge scores than those who have done nothing on the subject. We also checked that it did not depend on the questions which were left unanswered. As regards seeing the exhibition, the results of knowledge of Environment 8 also had a negative effect and corresponded to a worsening of the answer.

It seems that classroom preparation did not mesh with the concepts evaluated. Another factor to consider in these results is the teacher's awareness of being examined, which affected more those groups which had prepared than those which had not, with the latter group being more spontaneous and disposed to answer a subject from their own personal experiences. These results, which may seem surprising, were subsequently and meticulously contrasted using ANOVAs, for possible factors that were not considered that may have accidentally had a significant influence on the composition of the students of each experimental subgroup. It can be stated that these factors had no influence on the results provided by the students.

CONCLUSIONS

In overall terms, the exhibition on "Ecology" worked well, since 89% of the people who completed the questionnaire

said they had liked it and intended either to come back or recommend it to others.

Environment 4, "The selection game", was the most successful part of the exhibition because people found it very attractive and interesting. It caused surprise because its content was easily understood, something that people had not expected. It also has a participative quality which allowed the visitor to experiment.

Environment 8, "An important actor: man" was not liked by visitors. Criticism was mainly directed at the presentation, which was found to be unattractive and boring. Its conceptual content did not match the expectations, and people found it difficult to understand, and poorly expressed.

The opinion of volunteers is the same as the opinion expressed by students for almost all the aspects studied.

It has been shown that the probability of an opinion being expressed about an environment in the exhibition is proportional to the time devoted to that environment. Similarly it has been observed that the opinion is more likely to be positive the more time is spent in the environment in question.

The formal characteristics of the presentation are related to the impact. For the whole population, the probability of giving an opinion on an Environment is directly related to its size and inversely related to the density of information (proportion of underlined text). The opinion of surprise is not related to any of the studied descriptors.

Public opinion seems to be shaped by series of factors and descriptors that act together, which in the case of the exhibition studied are the following: a) the complexity of the subject matter; b) previous knowledge and the interest of the public in the subject; c) the coherence between title and content from the point of view of public expectations; d) success in the quality of design and coherence amongst the parts and the overall composition; e) use of appropriate examples linked to everyday life.

There is a direct relationship between the opposite impact for Environments 4 and 8 and the knowledge remembered for each one of them. All groups of students (EGB, BUP, COU, Training teachers) obtained better marks for Environment 4 concepts after seeing the exhibition (the part most liked). None of the four groups of students improved their qualification for Environment 8 questions after visiting the exhibition. This was the part with the most negative impact. Furthermore, teacher trainees achieved worse results for knowledge of Environment 8, after seeing the exhibition.

Previous knowledge of "ecology" obtained at school affected (differently) the level of knowledge evaluated after seeing the exhibition. Differences are found among levels. Those students of BUP with a previous preparation on ecology achieved significantly better results than those who had not prepared it, while the teacher trainees who had not prepared ecology in class, obtained better marks after the exhibition than those who had been prepared.

A short explanation on how to look at an exhibition, given before the visit, had a positive and significant effect on the marks obtained by the students of BUP for Environment 4. Students of BUP seem those most receptive to all the factors considered.

Students using the exhibition as a complement to their formal education only benefited if they liked the exhibition (in this case studied environment by environment). The amount of conceptual information is critical. It seems that the proportion or density of written information must be the least possible and that the overall density of conceptual content of each environment or exhibit must be low. For practical purposes one sees that if a topic is complex and involves many new concepts, it has to be split into several

environments or exhibits and has to be distributed in a large enough space in order to obtain a decreased density of information. This should be done with the subjects included in Environment 8 when possible in any future exhibition. Many of the ideas included in "An important actor: man", such as "external or exosomatic energy", did not reach the public, although we know the great importance the author gives to them (MARGALEF, 1985b).

Moreover, if the presentation and content do not match the expectations (the topic as it was learned formally at school) then people do not only dislike the exhibition, but they do not learn anything either. This result is in itself a major criticism on some widespread methods in formal learning (or teaching), where students are prepared against anything new or different from what is said in class or in textbooks. Students feel self-confident when they are aware of their ability to match the teacher's preferences or opinions (those of textbooks or school) but they are unable to express in an examination something that is not what they have been taught, even if it is not necessarily contradictory. The question is most alarming when we think that the students presenting this response to the experiment on learning about an exhibition are those who are being prepared to follow a career as teachers.

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