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Evaluating Expectations on Museum Communication about Geo- and Environmental Sciences

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Abstract

In order to design an exhibition on earth and environmental science research, we conducted an online survey on the thematic interests of potential future visitors. The 775 valid responses we received were used to analyse the level of interest in predefined subject areas. In addition, further topics were extracted from open questions that were mentioned by the survey participants as being particularly interesting. The analysis of these interest levels in relation to the socio-demographic distribution of the participants provides an indication of which topics should be discussed in a future exhibition. The data also allows conclusions to be drawn about the development of strategic communication concepts. These will be able to support the processes from initial contact through to a participatory dialog. It is also of particular interest that the data obtained in this survey allows the hypothesis that topics for which the participants indicated a low level of interest may not actually be uninteresting, but rather result from a lack of prior knowledge. The study presented here therefore leads to the conclusion that such topics should be addressed in communication with visitors to an exhibition in order to build up prior knowledge and increase interest in these topics.

Keywords: science communication, expectation, museum, exhibition, topical relevance

1. Introduction

Museums fulfil various functions: They collect, preserve, research and communicate, according to the German Museums Association (DMB) in its guidelines for museums (DMB 2006) and others (e.g. Kirchberg 2016, who is quite critical of this). Sheng & Cheng (2012) also observe that museums '... gradually acquired visitor-based roles instead of museum-based roles.' From this new, visitor-centred self-image follows an increasing need to analyse the visitors themselves – what they expect from the museum, what experiences they associate with museums and how mediated content is received by visitors. The study presented here deals with the first point mentioned: the analysis of visitors' expectations of an exhibition. To this end, we concentrate on content-related expectations, although we also asked about expectations regarding other elements of the 'experience' (Liu 2008). In fact, in addition to Hood (1983), we also see the fulfilment of content expectations as a criterion for a desired experience.

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

The reason for conducting this study is based on the idea of integrating visitors' expectations into the exhibition design and concept as early as possible. The usual approach to developing an exhibition is for a team of exhibition experts to discuss possible content with scientists, consider ways of communicating it and then design exhibits, audio-visual content, texts, images and graphics. This is an exaggerated and simplified depiction of a thoroughly complex process. Nevertheless, the approach of defining themes and content from within, i.e. from the curatorial team or directly from academia, remains dominant in most cases. This does not necessarily have to be problematic. However, it often means that the topics that are actually interesting or relevant for visitors are not taken into account. Instead – analogous to the gatekeeper function of journalism (Lippman 1998) – a research-centred decision is made as to which topics are communicated.

As part of the conception of a new exhibition on geosciences and environmental sciences, which is being jointly designed by the Bavarian Natural History Collections (SNSB) and the Ludwig-Maximilians-Universität München (LMU), the conception team has chosen a different approach. Although topics defined by the main research areas at the partner institutions are still addressed in the educational programs, the concept also aims to provide space for topics and content that are chosen according to the expectations and interests of the visitors themselves (cf. Liu 2008). The aim is to merge existing, more traditional exhibition concepts into a new, integrative and modern mediation concept (Thiemeyer 2016). The mission is to take up the concept of the forum and create an open, transparent space that invites participation and enables active engagement with the earth and environmental sciences through presentation and dialog. To achieve this, visitors must be motivated to think for themselves, to question critically and to develop new strategies for action and decision-making. This can be achieved if suitable topics based on the intrinsic interest of the visitors are proactively available and presented. In order to find these topics, an online survey was conducted in summer 2021 to identify these areas of interest. Clear thematic preferences were identified from the 775 valid responses1. By combining the analysis of socio-demographic data with content-related information from the participants, it was also possible to identify approaches that will allow a target group-specific approach. This will enable the GeoForum2 concept team to develop a strategic communication concept.

2. Theoretical background

In the empirical social sciences, qualitative content analysis (QCA) and multivariate statistics are now established tools for analysing the attitudes and expectations of specific target groups (see Schnell et al. 2011). On the basis of surveys (in-person, written, online, audio-visual), samples of the relevant target groups are approached and interviewed. In combination with socio-demographic information, correlations between, for example, age and interest in certain topics can be interpreted. QCA becomes more complex if, in addition to the scalable information from closed questions (e.g. via Likert scales or others), open questions are also to be included in the analysis. The

[1] The responses are provided with ID numbers up to 784. However, some responses were not included in the evaluation because they were incomplete. Therefore, only 775 responses are included in the following analysis.
[2] Ludwig-Maximilians-Universität München (LMU) and the Bavarian State Natural History Collections (SNSB) are currently working on an innovative exhibition concept that will move into the new Geo-Campus to be built in the center of Munich in the next few years. The exhibition will be called GeoForum and will present current geoscientific research and also serve as a communication partner for the public on topics relating to earth and environmental sciences.

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

analysis and interpretation of such open questions require the coding of answers, which then allow a quantitative-qualitative statement to be made about the corresponding questions. A combination of closed and open questions was used in this study.

2.1 Problems of operationalization

Especially when using simple Likert scales, it can be observed that a so-called 'central tendency bias' (CTB; Hollingworth 1910) occurs in self-assessments and queries about interest or expectations. According to Xiang et al. (2021), the CTB is a '… well-known empirical regularity that perceptual judgments are biased towards the centre of the stimulus distribution.' This means that survey participants are more likely to give a mean value as a result than a value in the extreme ranges of the Likert scale. The tendency towards the centre results in a reduction in variance - it must therefore always be taken into account in the statistical analysis.

In addition to the tendency towards the middle, 'social-desirability response bias' (SDRB) also comes into play (Gordon 1951, or more recent Bernardi & Nash 2023) when attitudes are asked about in a wider social context. Especially when the sender of the survey is seen as dominant or very competent by the participants, answers are given in a way that seems to be desired by the sender in the perception of the participants. Gordon (1951) writes: '... if an individual, who is motivated to make socially acceptable responses, is forced to select one of the items as being least like himself, he will select the item that he perceives to be most derogatory ...'. This effect is very strong in the context of moralizing or ethical questions (Bou Malham & Saucier 2016) - in the context of the survey presented here, it is to be expected that the SDR effect is rather less pronounced. Nevertheless, since the sender of the survey discussed here identifies itself as a consortium with close ties to geoscientific research, it can be assumed that the survey participants are more likely to indicate a 'high interest' in a self-assessment (in the sense of 'this seems to be expected by the sender') than to respond with 'no interest'. Based on this observation, responses indicating 'no interest' can be considered very robust and reliable, while responses indicating 'high interest' are less robust.

The Kruger-Dunning (in which one's own competence is overestimated; Kruger & Dunning 1999) as well as the Imposter-Syndrome (assessing oneself as less competent than one actually is; Clance & Imes 1978), which counteracts this, cannot be determined here in terms of their effect and qualitative influence. In a critical interpretation of surveys such as the one presented here, however, both effects should always be taken into account.

3. Methodology

The raw data and the revised data (Schneider et al. 2024) discussed in the following chapters can be viewed and accessed via the Open Data LMU repository.

3.1 Sampling Methodology

The participants in the online survey were contacted via the e-mail distribution lists of the participating partner institutions and the curatorial team's professional and private e-mail distribution lists. It should be noted that the structures of these mailing lists resulted in a clear focus on people with an interest in geosciences and natural sciences or with a close connection with those communities. Although people without a high affinity for the natural sciences were also reached by approaching teachers and K12-students as well as by using private

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

mailing lists, this fact must be taken into account when interpreting the data. Why the use of these mailing lists nevertheless makes sense is discussed in more detail in Chapter 5.

The survey was carried out using the online tool evasys. To test the structure, handling and validity of the survey, a test group consisting of around 35 participants was first asked to take part in the online survey. We took the constructive criticism expressed in this test run seriously and reformulated some of the questions in line with the feedback from the test group. An example of such an adaptation is the standardized formulation of the subject areas: based on the experience of the test run, the formulation was simplified without giving examples of topics and research object. As it turned out that only minor adjustments to the survey were necessary based on the criticism, the 35 participants in the test group were also included in the subsequent evaluation.

A rudimentary set of socio-demographic information was requested from all participants. This included information on the participants' age and gender, place of residence, profession and self-assessment of their prior knowledge of geoscientific topics. This was followed by a 5-point Likert scale to assess interest in 45 thematic fields.

This was followed by further open questions that asked about other topics, as well as expectations regarding exhibits or the exhibition infrastructure. The open questions allowed participants to indicate topics that they themselves found particularly interesting. Participants were also able to name topics that were not mentioned in the previous catalogue of topics, but which are of interest to them. The data on the infrastructure of an exhibition has not yet been included in the following analysis and will be examined in detail at a later date.

Answering the questions was voluntary, so participants could skip questions. Accordingly, the amount of valid data available varies from question to question.

3.2 Evaluation Methodology

In the following, we discuss the procedure for evaluating both the closed question types and the open questions. It should be noted at this point that multiple answers were possible in the interpretation of open questions with regard to the participants' socio-demographic information on their profession. For example, participants could identify themselves as students or teachers as well as academics. Accordingly, the information provided by these participants was integrated into both the cohorts of students and teachers as well as the cohort of academics.

3.2.1 Likert scale rating - Topic catalogue

When evaluating the topics we provided, the survey participants were able to indicate their interest in each of these topics individually using a 5-point Likert scale. The answers could be rated from ‘I am very interested’ (with a rating of 1) to ‘I am not interested at all’ (with a rating of 5) as well as with more neutral ratings (I am somewhat interested, feel neutral, not very interested) in the middle (with a rating of 2 to 4) (Table 1). This is referred to below as the interest level and enables a quantitative evaluation based on the ordinal-scaled data, which allows a quick overview of the general and cohort-related interest in these topics.

5-step Likert Scale					
normative value	very interested	somewhat interested	neutral	not very interested	not interested at all

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

operative value	1	2	3	4	5

Table 1: 5-point Likert scale using the example of the level of interest survey

Some of the topics surveyed can be merged and summarized into generic topics. For example, the pre-formulated topics Raw Materials, Formation of Deposits, and Raw Material on Site can be merged into the generic topic of Raw Materials. This example already shows one of the obstacles of this survey: some topics are not well defined and might be perceived and interpreted by the survey participants in quite different ways. The introduction of generic topics seeks to address this issue. In order to allow an analysis of these generic topics, mean values for the level of interest in each of the integrated topics were calculated for each participant. This was done by calculating the simple mean value, without any weighting. Only the valid values are included in this calculation. The mean values calculated in this way can now be interpreted across or within the respective cohorts.

It is also interesting to analyse the standard deviations, which represent a measure of the spread of interest in a topic. A low dispersion means that the participants in the survey show a more homogeneous indication of interest in this topic than for a topic with a high dispersion. However, due to various social effects (see Chapter 2.1), these values can only be interpreted qualitatively.

3.2.2 Open Questions

In addition to the closed questions, the participants' interest and expectations were also evaluated using open questions. These were primarily intended to identify topics that were not covered in the closed questions but were nevertheless of great interest to the survey participants. The evaluation of the open questions section of the survey is also important as it gives participants an additional chance to mention topics that they find particularly interesting (including those that may have already been addressed previously). In order to analyse such open questions, we used the established methods of Qualitative Content Analysis (QCA). For this purpose, a codebook was created that translates free text answers into a numerical code. The codebook was developed jointly by the people responsible for coding (coder) – a routine that results in a more reliable coding due to agree on terminology and interpretation. A sample of the data set was first coded by coder A. Another sample with slight overlap to the first sample was coded by coder B. Subsequently, a sample of the initial coding of A respectively B was coded again by a third coder C, so that the validity of the coding could be checked. An analysis of these intercoder reliabilities shows that there is very good to excellent reliability between the different coders (Table 2). This means that subjective distortions due to individual interpretations of the elements of the coding book can be regarded as very low.

Intercoder-Reliability			
Coder	A-C	B-C	B-C
related question	8.1	8.3	8.2
valid coding by both	106	53	76
Cronbach's Alpha	0.79	0.96	0.85
Cronbach's Alpha Consistency	acceptable	excellent	good

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Table 2: Intercoder reliabilities between the three coders A, B and C. The reliability was checked for sample questions as mentions in row 2; (Dataset: visitors_expectations_openQ.csv)

As part of the coding of the open questions, we were able to identify different levels of content (the so-called granularity). Accordingly, and similar to the above-mentioned procedure, generic topics were defined that summarize the answers of a topic area. For example, answers that mention sub-topics such as synthetic minerals, crystal structure or biomineralization are assigned to the generic topic of minerals and crystals.

It is crucial for the interpretation of the open questions that we mention here that multiple answers were permitted. This means that a participant could mention several topics in the open question, each of which was treated as a separate answer in the coding. In addition, some participants preferred not to answer open questions. The data set of 775 participants ultimately contains

- 393 topic-related items in the responses for question 8.1
- 249 topic-related items in the responses for Question 8.2
- 303 topic-related items in the responses for question 8.3.

The separate coding of multiple responses allows the content mentioned to be linked to socio-demographic data (in particular age and previous knowledge).

4. Results

4.1 Sozio-demographics

All participants were asked to provide socio-demographic information on the categories of age, gender, profession, place of residence and a self-assessment of their own previous knowledge. The question about the age of the participants was open (numerical answers only). The question about gender allowed for clear indications of male, female, diverse or no indication. The profession and place of residence were asked as checkboxes (e.g. residence was coded as Munich, Munich area, Bavaria, Germany, international).

4.1.1. Age and Gender

The participant group is made up of 380 female and 380 male participants - three participants identified themselves as diverse, twelve preferred not to provide any information on their gender (11 participants responded with ‘prefer not to answer’; one response showed an empty field). For a meaningful interpretation of possible correlations between age and level of interest, the respondents were grouped into cohorts, each covering 20 years. This results in four cohorts that allow certain trends to be identified.

The age distribution of the participants reflects the demographic data of the Federal Republic of Germany as far as the age groups over 20 are concerned. In contrast, the age groups between 21-40 years are more strongly represented in the survey, while the age group under and equal to 20 years is significantly weaker. 43 participants belong to the age cohort younger or equal to 20 years, 270 to the cohort 21-40 years, 260 to the cohort 41-60 years and 168 to the cohort 60+. 35 participants did not provide any information (Table 3). The age group under 15 was

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

represented by only one participant. This is partly due to the fact that the actual target group of the survey was people over the age of 16, as younger people would have needed their parents' consent to take part in such a survey. Obtaining this consent would not have been feasible in the selected online format.

Age (n=775)	cohort	count	Percentage of valid entries
valid	≤ 20	43	5.5
	21-40	270	34.8
	41-60	260	33.5
	>60	168	21.6
	none	35	4.5

Gender (n=775)	cohort	count	Percentage of valid entries
valid	prefer not to answer	11	1.4
	Male	380	49.1
	Female	380	49.1
	Diverse	3	0.4
	empty field	1	

Table 3: left: Distribution of respondents by age cohort; right: Distribution of respondents by gender (Dataset: visitors-expectations.csv)

4.1.2. Profession

Participants were asked to indicate one or more professions. Nine categories were specified: school pupils, geoscience students, students of other subjects, scientists, museum staff, teachers, lecturers, people interested in geosciences and other (Table 4).

These categories are not always very precise and clear-cut, which is why multiple answers were allowed here. In addition, these categories are not further defined, which makes it difficult to analyse the statements on thematic interest in relation to professions such as lecturer, geoscientifically interested or other. Similarly, the assignment of participants to geoscience students, students of other subjects or the distinction between students and teaching staff is not always clear.

Profession	count	Percent of respondents
Students (K12)	14	1.8%
Students Geoscience	102	13.2%
Students other	66	8.5%
Scientists	204	26.3%
Museum Staff	89	11.5%
Teachers	96	12.4%
Lecturers	80	10.3%
Interested in Earth Science	271	35.0%
others	118	15.2%

Table 4: Distribution of respondents according to their own statements about their profession; multiple answers result in 1040 responses from 775 participants (Dataset: visitors-expectations.csv)

4.1.3. Previous Knowledge

The participants were asked to self-assess their competence in the geosciences. The question about prior knowledge was answered on a 5-point Likert scale (Table 5).

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Overall, and taking into account known effects in the empirical social sciences, it can be seen that expected results are reproduced here and that clear tendencies are confirmed when comparing the different professions. This becomes obvious, among other things, when comparing students of geosciences with students of other subjects: here it can be clearly seen that although students of geosciences assess their prior knowledge as only slightly above average, they are clearly above the values of students of other subjects. These observations lead to the conclusion that the self-assessment of competence in the geosciences provides robust results.

Profession and pre-existing Knowledge		great knowledge	somewhat knowledgeable	neutral	not very knowledgeable	no knowledge at all	no data
Students (K12)	*count*	*0*	*0*	*8*	*3*	*2*	*0*
	percent	*0.0%*	*0.0%*	*61.5%*	*23.1%*	*15.4%*	*0.0%*
Students Geosciences	*count*	*36*	*42*	*18*	*4*	*0*	*0*
	percent	*35.5%*	*41.2%*	*17.6%*	*39.0%*	*0.0%*	*0.0%*
Students other	*count*	*7*	*10*	*22*	*20*	*7*	*0*
	percent	*10.6%*	*15.2%*	*33.3%*	*30.3%*	*10.6%*	*0.0%*
Scientists	*count*	*127*	*37*	*23*	*10*	*6*	*1*
	percent	*62.3%*	*18.1%*	*11.3%*	*4.9%*	*2.9%*	*0.5%*
Museum Staff	*count*	*32*	*14*	*16*	*19*	*8*	*0*
	percent	*36.0%*	*15.7%*	*18.0%*	*21.3%*	*9.0%*	*0.0%*
Teachers	*count*	*38*	*22*	*18*	*11*	*7*	*0*
	percent	*39.6%*	*22.9%*	*18.8%*	*11.5%*	*7.3%*	*0.0%*
Lecturers	*count*	*55*	*12*	*6*	*4*	*3*	*0*
	percent	*68.8%*	*15.0%*	*7.5%*	*5.0%*	*3.8%*	*0.0%*
Interested in Geoscience	*count*	*62*	*59*	*102*	*38*	*10*	*0*
	percent	*22.9%*	*21.8%*	*37.6%*	*14.0%*	*3.7%*	*0.0%*
others	*count*	*7*	*9*	*28*	*54*	*20*	*0*
	percent	*5.9%*	*7.6%*	*23.7%*	*45.8%*	*16.9%*	*0.0%*

Table 5: Correlation between profession and self-assessed prior knowledge of respondents (Dataset: visitors-expectations.csv)

The self-assessed level of interest of the museum employees is astonishing: Here, we see the highest rate of 'great knowledge" amongst all professions. An explanation for this could be found in the distribution process: The distribution lists used for the survey are generally also strongly influenced by the networks of the concept team employees – all of them involved in earth sciences themselves.

As employees from natural history museums and other museums are particularly involved here, a stronger tendency towards a high level of knowledge amongst participants from this profession would have been expected. The fact that around a third of respondents in this cohort (Museum Staff) describe themselves as having little to no prior knowledge also seems unusual in respect to the option of multiple responses. In addition, a closer analysis of this cohort shows that around half of the museum employees surveyed also classified themselves as geoscience students or scientists. This indicates that the museum employees perceive themselves as uninformed - a possible effect that could relate to the imposter syndrome (Clance & Imes 1978, for more recent research on the Imposter Syndrome see Walker & Saklofske 2023).

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

4.2. Evaluation of questions on predefined topics

The evaluation of the closed topic survey (of the topics predefined within the survey) shows that some topics are characterized by a high level of interest - other topics, on the other hand, are rated as less interesting by the participants (Table 6). This initial analysis was carried out without differentiated consideration of the various participant groups, but already reveals remarkable differences. For example, topics can already be identified here that simplify initial contact in mediation. Topics that are highly relevant to everyday life (climate change, raw materials, everyday relevance), spectacular geoscientific phenomena (volcanism, plate tectonics), but also certain basic research topics (origin and development of life - keyword evolution) are met with a high level of interest. In contrast, participants find a heterogeneous selection of topics less interesting (e.g. artificially produced crystals and materials, biomineralization and raw materials on site).

Descriptive Statistics			
	N	Mean	Std Dev
Methods and Instruments	771	1.92	0.90
Social relevance	769	1.94	1.01
Relevance for Everyday Life	769	1.61	0.76
LMU and SNSB Topics	769	2.08	0.93
Great Exhibits/Objects	768	1.94	0.89
Regional Reference	770	1.96	1.02
Interface to Other Sciences	770	2.04	1.05
Fossils	768	2.05	1.01
Evolution of Life	773	1.77	0.90
Mass-Extinction of Species	768	1.98	0.95
Evolution of Plants	769	2.20	1.02
Biomineralization	766	2.49	1.04
Climate change	774	1.62	0.85
Raw Materials	770	1.83	0.93
Satellites	771	2.27	1.05
Renewable Energies	772	2.04	1.04
Radioactive Waste Disposal	772	2.23	1.06
Natural Cycles	766	2.17	1.04
Ocean	771	1.98	1.01
Structure of the Earth	773	1.79	0.81
Chemistry of the Earth	772	2.08	0.99
Planets	773	1.95	0.96
Solar System	763	1.88	0.92
Plate tectonics and Volcanism	770	1.65	0.84
Formation of Deposits	770	1.99	0.94
Aesthetics of Minerals	767	2.28	1.12
Building Materials	770	2.40	1.13
Artificial Minerals	768	2.55	1.17
The Alps	774	1.82	0.87
Volcanism in Bavaria	774	1.87	0.92
Ries Crater	773	1.93	0.95
Franconian Jurassic	767	2.13	1.05
Ancient elephant	768	2.20	1.10
Raw Materials on Site	768	2.29	1.05
Tsunamis	768	2.21	1.01
Landslides	769	2.14	1.04
Floods	764	2.27	1.02
Earthquakes	767	1.95	0.92
Meteorite Impacts	767	2.03	0.99
Volcanism	766	1.82	0.93
Metamorphism of Rocks	773	2.05	1.01
Magma	773	1.86	0.91

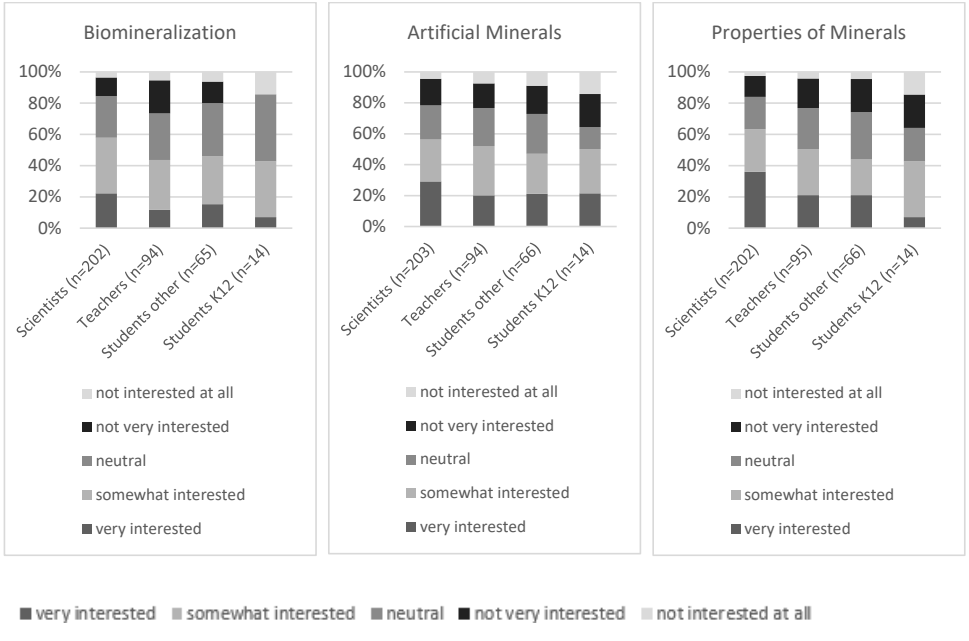
https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Mountain Formation	769	1.88	0.89
Salts Near the Surface	769	2.15	0.99
Erosion	770	2.01	0.97

Table 6: Mean values of the interest level of the topics, arranged in the order of the query. N= number of valid ratings; mean= statistical mean as the sum of the valid ratings divided by N; Std Dev = standard deviation; please note that the highest interest is coded as 1, the lowest interest as 5 (see 3.2.1) - therefore a low mean value means that the respondents rated this topic with high interest. N is the number of valid answers - as some participants did not want to answer at all (empty field), N varies from topic to topic. (Dataset: visitors-expectations.csv)

It is noticeable that topics rated with a high average interest tend to have a low standard deviation: the 10 topics with mean values of less than 1.87 show standard deviations of 0.93 or less. In contrast, topics that were rated with lower interest tend to show a higher standard deviation: the 10 topics with mean values above 2.2 show standard deviations greater than 1.01 and up to 1.17. This indicates that topics with a lower average interest were rated very differently in different groups (regardless of age, gender, profession or similar assignment to cohorts). At the same time, this may also be related to the fact that, due to the tendency towards the middle, shifts towards average values have taken place here, while the information on low interest can otherwise be regarded as rather robust. However, this also results in a greater dispersion in the data itself - the standard deviation increases accordingly.

In a next step, the topics with a higher standard deviation were therefore analysed in more detail. The first step was to compare the interest levels indicated by the professions of scientists, geoscience students, teachers, students of other subjects and pupils. For the three topics with the lowest average interest (biomineralization, artificially produced crystals and materials, structure and properties of minerals), scientists had the highest proportion of participants who found these topics very interesting (Figure 1). In contrast, only a few teachers, students of other subjects and school pupils (K12) find this content very interesting – significantly more respondents from these professions consider these topics to be of little or no interest.



https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Figure 1: Comparison of the interest levels of scientists, teachers, students of other subjects and pupils (K12) on topics with a higher spread of interest levels (Dataset: visitors-expectations.csv)

The different interest levels of scientists and teachers are particularly striking in these topics and it is noticeable that around 10% fewer teachers rate these topics as very interesting. At the same time, however, the difference in the interest level 'no interest' is only very slight.

For comparison, the distribution of interests in the various professions was also analysed for topics with a high level of interest and a low standard deviation. The example of climate change (in geological history and today) shows that the level of interest here is quite high across all professions (Figure 2). Basically, it can be seen that the groups of teachers and pupils in particular show a significantly greater interest in the topic of climate change than the other groups. Only in the group of scientists and lecturers is there a small proportion of participants who are not interested in this topic. However, in view of the low representativeness of the sample, it is not possible to draw conclusions here about the often-cited climate change fatigue (Hornsey & Fielding 2020).

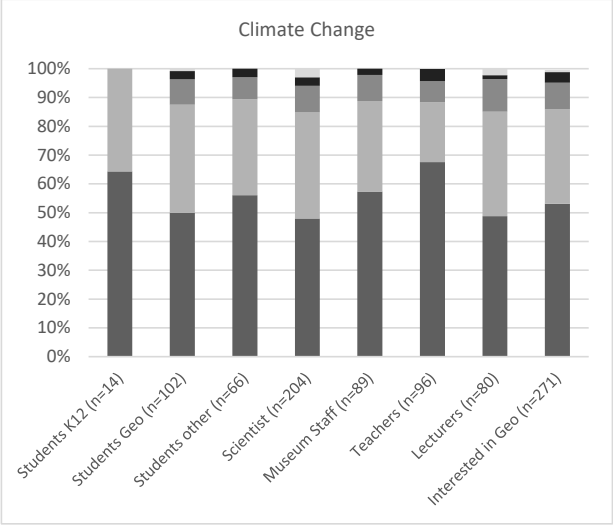


Figure 2: Comparison of the interest levels of the various professions on the topic of climate change. It should be noted once again that the 'profession' cohorts are not clearly defined, and multiple responses were permitted (Dataset: visitors-expectations.csv)

In addition to analysing different levels of interest between the professions, an analysis can also be carried out in relation to the age of the participants. It can be seen that there are some strong differences between age cohorts. Younger participants often rate the topics surveyed very differently to older cohorts. This is noticeable, for example, in the generic topic area of raw materials: the topics 'Raw Materials and their Formation and Deposits' and 'Regional raw material occurrence' are rated as less interesting by the age cohort under 20 years (Figure 3).

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

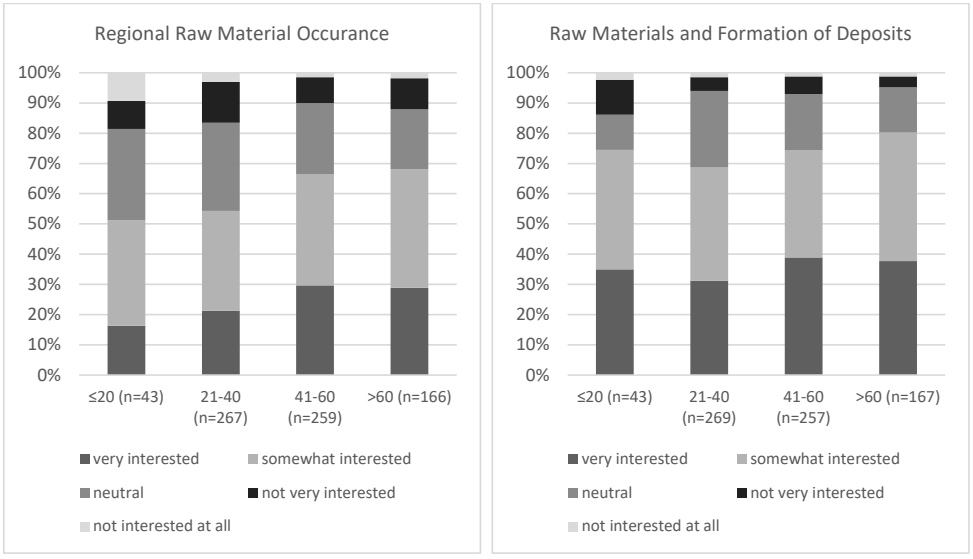


Figure 3: Occurrence of interest in topics related to raw material – interest in the overall topic of raw materials increases with age. (Dataset: visitors-expectations.csv)

It is noticeable here that the topic with a stronger regional focus (Regional Raw Material Occurrence) was rated as 'Not interested at all' and therefore significantly less interesting than the more basic topic (Raw Materials and Formation of Deposits).

4.3 Results from open questions about additional expectations

The answers to the open question 8.1 'Are there any other topics/contents that you would like to see in an exhibition about the geosciences?' were divided into various sub themes using the codebook. Some sub-themes were later merged into generic themes (see Chapter 3.2.2). When looking at the number of answers in the various generic topics, it is noticeable that a very large proportion of the answers (37.0%, N=145) of the total of 392 coded answers) fall into the generic topic of 'Earth and Mankind' (Table 7). The answers in the earth-environment-human area are divided into 22 sub-topics, some of which coincide with the topics of the closed questions. However, there are also some additional topics, which justifies the approach of using an open questionnaire in addition to a closed questionnaire. The most frequently mentioned topics among the 22 sub-topics in the earth-human-environment area were 'Raw materials, reserves and prospection', 'Climate change', 'Geosciences in politics and society', 'Species extinction - Anthropocene', 'Protection of landscape and environment', 'Drinking water' and 'Geothermal energy/renewable energies'.

In the answers to this open question, some topics were also mentioned that go beyond the list of topics in the closed questions. Among these, the sub-topics 'Study and career in geosciences', 'Connection to other disciplines' and 'History of science' were mentioned more frequently.

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

	Structure and Dynamics of the Planet	Processes and Cycles	Crystals and Minerals	Earth and Mankind	Evolution	Regional Relevance	others
Percentage	7.9%	9.4%	6.4%	37.0%	5.9%	8.4%	27.8%
n=392	31	37	25	145	23	33	109

Table 7: Number of mentions of generic topics in the open question 8.1 of the survey in relation to all open answers given (Dataset: visitors-expectations_openQ.csv)

5. Discussion

5.1. Socio-demographic trends in interest levels

In the following, we will look at trends that can be identified by comparing the information on the respective topic levels and the respective demographic data. Here, we focus primarily on a possible correlation between interest level and age as well as interest level and prior knowledge. We will only briefly discuss possible correlations between interest level and profession.

5.1.1. Age and Interest Levels

In general, it can be said that there is a high level of interest in the specified geosciences and environmental sciences topics across all age groups. This becomes particularly obvious when asking about the level of interest in the topic of climate change. Here, well over 87% of respondents in all age groups expressed great to very great interest (Table 8). This finding speaks – even if one takes into account the particular composition of the sample – against the climate change fatigue postulated by some studies (Kerr 2009, Hornsey & Fielding 2020, Hoppe & Neverla 2023).

Age x Climate Change Age		*very interested*	*somewhat interested*	*neutral*	*not very interested*	*not interested at all*
≤20	*count*	*28*	*13*	*2*	*0*	*0*
	percent	*65.1%*	*30.2%*	*4.7%*	*0.0%*	*0.0%*
21-40	*count*	*145*	*87*	*24*	*9*	*5*
	percent	*53.7%*	*32.2%*	*8.9%*	*3.3%*	*1.9%*
41-60	*count*	*145*	*82*	*22*	*7*	*3*
	percent	*56.0%*	*31.7%*	*8.5%*	*2.7%*	*1.2%*
>60	*count*	*97*	*53*	*12*	*6*	*0*
	percent	*58.4%*	*31.9%*	*7.23%*	*3.61%*	*0.0%*
no answer	*count*	*13*	*16*	*3*	*1*	*1*
	percent	*38.2*	*47.1*	*8.8*	*2.9*	*2.9*
all	*count*	*428*	*251*	*63*	*23*	*9*
	percent	*55.3%*	*32.4%*	*8.1%*	*3.0%*	*1.2%*

Table 8: Cross-tabulation of age and level of interest in climate change. (Dataset: visitors-expectations.csv)

The analysis of the topic of 'regional relevance' shows that young people are less interested in the frequently invoked regional relevance of a topic (Table 9). The regional reference, although generally rated as interesting, is rated as uninteresting by an unusually large number of respondents in the under-20 age group. 21% of those under 20 do not consider the regional reference to be interesting. In contrast, only 10.3% of respondents across all age groups do not rate the regional reference as interesting.

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Age x Regional Relevance						
Age		very interested	somewhat interested	neutral	not very interested	not interested at all
≤20	count	14	13	7	9	0
	percent	32.6%	30.2%	16.3%	20.9%	0.0%
21-40	count	82	84	65	35	3
	percent	30.5%	31.2%	24.2%	13.0%	1.2%
41-60	count	120	81	34	21	3
	percent	46.3%	31.3%	13.1%	8.1%	1.2%
>60	count	84	62	13	5	2
	percent	50.6%	37.4%	7.8%	3.0%	1.2%
No answer	Count	19	10	3	0	1
	Percent	57.6%	30.3%	9.1%	0.0%	3.0%
all	count	319	250	122	70	9
	percent	41.4%	32.5%	15.8%	9.1%	1.2%

Table 9: Cross-tabulation of age and level of interest regional reference. (Dataset: visitors-expectations.csv)

This observation suggests that younger age cohorts, who are shaped by globalization and a humanity that increasingly describes itself as a global society, attach less importance to regional issues. However, as the example of climate change shows, they are interested in issues relating to global challenges. This observation is important as it allows a more targeted approach to certain age cohorts. According to the example discussed here, young target groups can be reached less effectively via the regional relevance of a topic. Rather, the need for information, which is expressed by a high level of interest, should be addressed in a targeted manner in order to then allow possible follow-up communication on other topics. However, as we will discuss in more detail below, this consideration only applies to the so-called initial contact.

5.1.2. Correlation between interest in generic topics and prior knowledge

With the help of the correlation analysis between the variables of prior knowledge and the generic topics (see Chapters 3.2.1 and 3.2.2) taken from question 8.1, it is possible to draw certain conclusions about the level of interest in certain topics if pre-educated target groups are to be addressed. The construct of prior knowledge was defined in the survey itself as 'prior knowledge in the geosciences'. For most topics, it can be seen that interest increases when respondents rate themselves as having a higher level of prior knowledge (Table 10).

	Structure and Dynamics of the Planet	Processes and Cycles	Crystals and Minerals	Earth and Mankind	Evolution	Regional Relevance	Others
Pearson Correlation r in Respect to Pre-existing Knowledge	0.210	0.076	0.224	0.024	-0.039	0.189	0.019

Table 10: Correlation between self-assessed prior knowledge and interest in the main topics – A positive r value (Pearson Correlation) higher than 0.05 means that interest in the corresponding topics increases with more prior knowledge. A negative r shows that interest in a topic decreases with more prior knowledge. (Dataset: visitors-expectations_openQ.csv)

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

However, the topic of evolution is an exception here: the negative correlation indicates that respondents who state a higher level of prior knowledge are less interested in topics relating to evolution. Current studies show that religion and belief may play an important role in the level of interest in this topic area (Kuschmierz et al 2021, Gefaeli et al 2020).

The topic of the structure and dynamics of the Earth shows a moderate positive correlation between prior knowledge and interest. This may be due to the fact that the complexity and interdependence of various processes and structures in the Earth's interior can only be recognized with prior knowledge, while the perception of these dynamics is only weakly pronounced with only little prior knowledge. In other words, it seems to be the case that a complex topic only becomes more attractive with a certain level of prior knowledge.

5.1.3. Correlation between interest in topics and profession

The detailed analysis of the three topics with the lowest average interest (biomineralization, artificially produced crystals and materials, structure and properties of minerals) in respect to the level of interest of different professions can be a starting point for targeting certain professional cohorts. Teachers, for example, show the greatest interest in topics that are anchored in the school curriculum. On the other hand, topics that are considered particularly interesting by scientists, for example, but are not represented in the curriculum, are rated as less interesting by teachers. In order to specifically address the target group of teachers, the curricula must be addressed in the content of an exhibition or accompanying programs.

The slightly lower level of interest in the topic of climate change among geoscience students, geoscientists and lecturers is possibly due to the fact that the topic is dealt with on a daily basis anyway. Climate change and the observation of its effects are currently the main driver of many scientific studies in the earth and environmental sciences. Conversely, however, this does not mean that geoscience students, scientists and lecturers are not interested in the topic of climate change.

5.2. Methodological criticism

Unfortunately, no socio-economic classification of the participants was asked in the survey. However, this proved to be valuable additional information in the interpretation of the data, which we would like to take up again at a later date.

A further problem arose due to the different operationalization of equally important questions in the survey instrument. For example, questions were used that were operationalized via Likert-scaled answers on the one hand and binary yes-no answers on the other. A transfer had to be made here. We were aware, that this transformation can be seen as a source of error and was therefore carried out with the utmost care.

5.2.1 Considerations regarding the composition of the sample

As part of several concept workshops, the GeoForum concept team defined a series of stakeholder groups, which essentially comprised the following communities:

- Geoscientific researchers
- Humanities researchers and artists
- Teachers, especially in the natural sciences
- Students and potential future students
- Decision-makers from university management and (education and science) policy

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

As there are numerous overlaps here with previous and current activities of the members of the concept team, it seems sensible and efficient to use existing distribution lists. Among other things, this also helps to ensure that the results of the survey can be incorporated into the exhibition and program design in a targeted manner and with minimal loss of impact, both on the part of the participants and in the subsequent integration of the survey results. As already described in Chapters 3.1. and 4.1., the use of existing distribution lists ensured that the composition of the sample (the survey participants) represented the GeoForum's target groups very well. Only the future students (pupils) are underrepresented (or absent). One of the reasons for this is that we have to consider the legal hurdles for surveys with minors, as well as the difficulty of reaching children and young people at all if we do not want to rely on the cooperation of schools. Although the interests of this target group in geosciences and environmental sciences are of great interest, we have decided not to approach schools. The 'non-visitors' represent another, equally interesting target group. However, it is almost impossible to reach them with surveys on the conceptual content of exhibitions and can generally only be achieved through direct interviews.

6. Conclusion

The analysis of the interest level of potential exhibition visitors shows that very different groups can be addressed by the range of topics on offer. However, it also seems advisable to communicate topics that are initially rated as less interesting in a targeted manner so that potential interest can develop in the first place.

High levels of participant interest in a topic make it possible to generate attention by addressing these topics and to directly address the expectations of the participants. These topics are therefore particularly suitable for initiating initial contact. Once this initial contact has been made, further topics can be set which are characterized, for example, by the potential for provocation (in a positive sense, see Ham 2007) or discussion. At the same time, the assessment of some topics as less interesting is much more difficult to interpret. In our opinion, the participants in the survey perceive certain topics as not interesting if they have little knowledge about these topics. For example, if the topic of biomineralization has been communicated little or inefficiently in advance (e.g. if it is barely present in traditional media), this can be interpreted as a lower level of interest. However, if a topic is presented in an active, entertaining and informative way in the media, the interesting facets and aspects of this topic become clear and interest in these topics increases.

In the exhibition design, which is ultimately the basis of this survey, this means that topics cannot be excluded in principle. However, there is actually a thematic sequence that can be used to develop contact with visitors from initial contact through establishing dialog to provocation and genuine follow-up communication. This contact hierarchy initially provides for addressing the audience on topics that are already characterized by a high level of interest. Further topics can then be placed and thus interest can be aroused. This step can be summarized with the quote 'Put there just a spark. If there is some good inflammable stuff, it will catch fire', which is attributed to the French Nobel Prize winner Anatole France. Once the audience's interest has been aroused, the provocation, in the sense of stimulating their own critical reflections on a topic, can finally take place (Mullin & Barr 2019).

In this sense, it is interesting – as an example for other topics such as Artificial Minerals, Radioactive Waste Disposal, or Biomineralization – to look at the relationship between age groups and interest in the topic of 'satellite remote sensing' (Table 11). 'Satellite remote sensing' can serve as an example of a topic that is highly

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

relevant in everyday life (e.g. in respect to navigation, communication, early warning, etc.) but is still perceived as rather uninteresting amongst the survey participants with 12.8% grading this topic as not very or not at all interested. This shows that although there is a fundamental interest in this topic, only around a quarter of respondents consider observing the Earth with satellites to be particularly interesting.

Age x Satellite Remote Sensing						
Age		*very interested*	*somewhat interested*	*neutral*	*not very interested*	*not interested at all*
≤20	*count*	*15*	*15*	*8*	*4*	*1*
	percent	*34.9%*	*34.9%*	*18.6%*	*9.3%*	*2.30%*
21-40	*count*	*74*	*88*	*67*	*29*	*12*
	percent	*27.4%*	*32.6%*	*24.8%*	*10.7%*	*4.4%*
41-60	*count*	*65*	*93*	*73*	*22*	*6*
	percent	*25.1%*	*35.9%*	*28.2%*	*8.5%*	*2.3%*
>60	*count*	*41*	*66*	*43*	*14*	*1*
	percent	*24.8%*	*40.0%*	*26.1%*	*8.5%*	*0.6%*
No answers	*Count*	*12*	*10*	*2*	*9*	*1*
	Percent	*35.3*	*29.4*	*5.9*	*26.5*	*2.9*
all	*count*	*207*	*272*	*193*	*78*	*21*
	percent	*26.8%*	*35.3%*	*25.0%*	*10.1%*	*2.7%*

Table 11: Cross-tabulation of age and level of interest in satellite remote sensing. (Dataset: visitors-expectations.csv)

If we compare this data with observations around exhibitions on this topic, a discrepancy emerges between theoretical queries and real interest during corresponding communication measures. In exhibitions, conversations and other communication measures, a great deal of interest in this topic area can be seen – but always when concrete communication takes place. In such situations, even people who had little interest in satellite remote sensing beforehand can be enthused about the topic.

One conclusion is that prior knowledge of the topic of satellite remote sensing may not be sufficient to arouse intrinsic interest. If respondents know little about the benefits, technology or methods used in remote sensing, the aforementioned proverbial spark for this topic cannot be ignited. However, if the interviewees are in the middle of a dialog, an exchange on the topic, aesthetic images, innovative technologies and the numerous applications relevant to everyday life as well as other factors arouse this interest. If one follows the theory that a possible lack of or insufficient prior knowledge strongly influences the level of interest in a topic, this has a formative influence on the conception of new science communication measures. For example, it is then urgently necessary to make certain topics of high relevance to everyday life, but which turn out to be of little interest in surveys, better and more intensively the content of new measures (see also Stewart & Lewis 2017). A low level of interest in studies such as this one should then become the starting point for new communication.

The data collected in this survey allows for further multivariate analyses. For example, a detailed investigation of a possible correlation of interests between subject areas and a detailed analysis of age structures within the professions is still pending. However, both can provide additional insights into possible approaches to target group-specific attention generation.

https://doi.org/10.5194/egusphere-2024-2567
Preprint. Discussion started: 2 October 2024

Data Availability

The data sets used for this study are published at Open Data LMU repository (Schneider et al. 2024).

Author contribution

GS, MKE, MK and LS designed the survey. LS and SS implemented the survey in the online-tool and accompanied the test phase as well as the actual survey. SS, LS and MJ checked the incoming responses, corrected the data for incorrect and incomplete data sets. LS, MJ and SS coded the answers. SS compiled the analysis, which was checked by LS and MJ. All authors did extensive editing of the final manuscript.

Competing Interests

The authors declare that they have no conflict of interest.

Ethical Statement

The authors are aware that on the basis of the correlations described in this article and in particular the selection processes described, conclusions can be drawn to a limited extent about the group of survey participants. However, as the survey was completely anonymized and no personal information was collected that could lead to the identification of the participants, we see no ethical concerns in the analysis of the survey results.

Acknowledgement

The data sets used for this study are published at Open Data LMU repository (Schneider et al. 2024).

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