Professor Joe E Heimlich and his colleagues from the Center of Science and Industry, a science museum in Columbus, Ohio, USA, are investigating how we learn when we visit informal learning institutions such as museums and aquariums. This project involved a series of studies spanning eleven years that focus on visitors’ experiences of visualisations together with their learning behaviour and data visualisation literacy.

Heimlich remarks that ‘the CRE’s laboratory is where people are learning’. The team’s location within a museum encourages the researchers’ creativity, enabling them to pilot-test their innovative research tools and instruments using COSI’s visitors as subjects. These trials enable the team to collect data that stands up to questions of rigour, meets all ethical standards, affords the correct depth of information, and is underpinned by learning theory. The CRE’s creative research builds on previous methods developed by other social science researchers analysing museum visitors’ behaviour.

CONTRIBUTING TO THE VISIT EXPERIENCE

The team insist that their data collection is integrated into the visitor experience and takes an engaging, fun approach that contributes to the visit experience. Games and gaming inspire their data collection instruments. The researchers explore various ways to collect information from visitors while still contributing to the visit experience and even visitor learning. An underlying goal for CRE is to give visitors an opportunity to participate in research in ways that make their interactions inherently meaningful.

Heimlich explains how their research methods evolve. Instead of carrying out one main study, the CRE team often engages in long-term collaborations and performs long sequences of individual studies, each providing a better understanding of a particular aspect of learning behaviour. These studies can involve extended collaborations with researchers from other institutions.

BIG DATA AND DATA VISUALISATION

One such extended collaboration has involved investigating the data visualisation literacy of visitors to science museums, as visitors can sometimes find data and visual presentations of data daunting to interpret. The widespread use of data visualisations for big data (large, diverse data sets that can grow rapidly) assumes that viewers can interpret and understand the visual – but is this assumption regarding viewers’ perception true? Collaborating with Dr Katy Börner’s laboratory at Indiana University, the CRE team have carried out research into big data and data visualisation over a period spanning eleven years. This has involved a long series of studies focusing on various aspects of data visualisation literacy and understanding the visitor's experience of visualisations.

The collaboration’s first study compared how familiar visitors were with different types of big data visualisations. Data visualisation involves the representation of data using graphics, such as charts and infographics. These visuals are intended to communicate complex data relationships in ways that are easy to comprehend. This multi-phase investigation took place within informal learning environments in three US science museums and aimed to find out how familiar visitors were with different visualisation types.

The researchers created a visualisation framework made up of twenty charts, graphs, geospatial maps, and network diagrams, timelines, and maps to showcase data for their visitors to help them understand social, temporal, and spatial relationships. In a second study, the CRE research team created the Simplicity-Familiarity Matrix to support museum professionals designing materials for exhibition spaces that facilitate the creation of visualisations that can be interpreted by visitors of all skill levels.

THE SIMPLICITY- FAMILIARITY MATRIX

Visitor studies were performed in four science museums and an aquarium using booklets containing the layers required to construct the visualisations. Visitors were shown the base layer and asked to interpret it. Then they were asked to describe what the base and first layer were communicating, then the base, first and second layers, and so on until the construction of the visualisation was complete. The team found that data visualisations ranged from simple to complex, while the data they depicted stretched from familiar to unfamiliar. By overlaying these two continua with visualisation running horizontally and familiarity running vertically, the researchers created a four-quadrant graphic, the Simplicity-Familiarity Matrix.

Data visualisations are intended to communicate complex data relationships in ways that are easy to comprehend. They are used in many different fields of work, including science, engineering, and business. They are used to present data in a visual form, allowing viewers to see patterns and relationships that might not be apparent in raw numbers. Data visualisations can be used to support decision-making, to communicate complex data to non-experts, and to engage the public in scientific research.

Museums often use visualisations such as infographics, timelines, and maps to help visitors understand the data and the stories behind it. By using visualisations, museums can make complex information more accessible and engaging for visitors. The CRE team’s work on the Simplicity-Familiarity Matrix helps museum professionals design effective visualisations that are easy for visitors to understand.

The CRE team invests in the learning behaviour of people visiting informal learning institutions such as museums, parks, zoos, nature centres, and aquariums.

H ow do we learn in non-formal, non-school settings? This question is at the root of work being carried out by Professor Joe E Heimlich and his colleagues in the Center for Research and Evaluation (CRE), based at the Center of Science and Industry (COSI), a science museum in Columbus, Ohio, USA. The CRE team investigates the learning behaviour of people visiting informal learning institutions such as museums, parks, zoos, nature centres, and aquariums.

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Matrix, that museum professionals can use to inform their designs for interpretive materials.

To enhance visitors’ experiences of data visualisations in museums, the CRE team recommend using easy-to-understand, well-designed data visualisations while providing appropriate guidance and support for visitors. They suggest employing a range of sensory modes, such as visual, kinesthetic and auditory, and using a selection of static and dynamic formats. They also advise that data visualisations are made relevant to visitors, for example through personalisation.

Participants tend not to criticise the finished visuals in an exhibit or a document, so the researchers wanted to investigate what level of finish draws the most honest criticism and critical examination from visitors so that studies with visitors would provide better data. The researchers also considered most interesting to compare with others. The researchers also explored how xMacroscope could be adapted to other physical experiences for data visualisation/literacy applications in other institutions.

Heimlich describes how these grant-funded projects resulted in new technology for creating real-time data visualisations with visitor-generated data. CRE was tasked with finding out what people understand about data visualisations, the types of data they are interested in comparing with others, and how they would want to compare themselves with. They also established how people make meaning from data visualisations and how they are to offer honest critiques of the visualisations. In addition to informing the project, these findings make a significant contribution to the body of knowledge concerning how people understand data visualisations, both in terms of academic literature and support for museum professionals designing informal learning materials for exhibition spaces.

The CRE research team created the Simplicity-Familiarity Matrix to support museum professionals designing materials for exhibition spaces.

Interviews with COSI visitors revealed that most people were prepared to share sensitive information with an evaluator in person. The participant’s gender and age were significant in predicting if they would be comfortable doing so with tablet questionnaires or in public settings. Examining the ethics of visitor choice as to whether and how they share their information prompted the researchers to also explore the social comparisons that visitors are willing to make with themselves. The data give insights into how museums should consider what information they require from visitors and how it is collected.

The RUN/WALK VISUALISATION EXPERIENCE
The Science Museum of Minnesota had developed an interactive Run exhibit where a visitor’s running time is automatically measured and then displayed. The National Science Foundation-funded project team developed a similar Walk experience that recorded an individual’s walking time as many museums discourage running. Using xMacroscope, visitors could choose to enter non-sensitive personal data into the system, eg, age and gender. This data appears onscreen as part of a visual, such as a graph or a map, so when someone crossed the finish line, they could see themselves in the data compared to other visitors. Participants could also manipulate the data using the xMacroscope technology to create their own data visualisations. To support this work, visitors’ social comparisons were investigated on two levels: who visitors chose to compare themselves with and with which data they considered most interesting to compare with others. The researchers also explored how xMacroscope could be adapted to other physical experiences for data visualisation/literacy applications in other institutions.

Heimlich and his team worked with COSI to conduct an experiment in which visitors generated data using the xMacrosope technology and then downloaded this data. The data was then displayed. The National Science Foundation-funded team recommended using easy-to-understand, well-designed data visualisations while providing appropriate guidance and support for visitors. They suggest employing a range of sensory modes, such as visual, kinesthetic and auditory, and using a selection of static and dynamic formats. They also advise that data visualisations are made relevant to visitors, for example through personalisation.

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Participants tend not to criticise the finished visuals in an exhibit or a document, so the researchers wanted to investigate what level of finish draws the most honest criticism and critical examination from visitors so that studies with visitors would provide better data. The findings of the study are still in draft format but revealed that fewer critical comments were made on well-designed, print-worthy maps, even though it had the same errors as the other, not quite finished versions. When the data collector pointed out the error, some visitors said they’d noticed it but didn’t want to mention it, while others thought they might be wrong rather than the map being wrong.

CREATING EXHIBIT EXPERIENCES WITH xMACROSCOPE
The CRE team’s most recent project involved implementing xMacroscope, an open-source platform for creating science centre exhibit experiences so that museum visitors can build and interpret visualisations using data generated by the visitors themselves. This research examined visualisations created from data visitors entered about themselves, and visuals of data generated from an active physical engagement (APE) activity. Among the research questions was: ‘Under what conditions and with what methods would museum visitors feel comfortable (and not comfortable) sharing sensitive information for the purposes of museum research or evaluation?’ The supporting literature review examined the sharing of personal information online and in person, and from perspectives such as social media and digital marketing.

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