Engaging Young Minds: Learnings from Data Visualization Workshops with Children and Teenagers

L. Lotteraner[1,2,3,*], R. Schuster[1,2,*] and J. Staudner[1,2,4,*]

[1]Visualization & Data Analysis, Faculty of Computer Science, University of Vienna, Austria
[2]Doctoral School Computer Science, Faculty of Computer Science, University of Vienna, Austria
[3]Department of Environmental Geosciences, Centre for Microbiology and Environmental Systems Science, University of Vienna, Austria
[4]Department of Statistics and Operations Research, Faculty of Business, Economics and Statistics, University of Vienna, Austria
[*]All three authors contributed equally.

Abstract

As the role of visual data representations in everyday information consumption is increasing, the importance of teaching data visualization literacy to lay audiences, such as children and teenagers, has grown. Research involving children and teenagers poses unique challenges, resulting in limited literature on teaching data visualization to this audience. This paper reports on the design and implementation of five educational workshops for children and teenagers aged 7 to 16, conducted over three years and teaching data visualization in the context of themes such as climate change, detective work, and social media. The workshops emphasized interactive learning and hands-on projects to engage participants and enhance their understanding of data visualization concepts and critical thinking skills. Key observations include the importance of tailoring content to developmental stages, using storytelling and gamification to sustain interest, and fostering collaboration through activities in small groups. By reflecting on these experiences, the paper contributes to the growing body of research on visualization education and offers practical resources for educators seeking to make data literacy more accessible to younger audiences.

CCS Concepts

• ***Social and professional topics*** → *Children; Adolescents; K-12 education; Informal education;* • ***Human-centered computing*** → *Information visualization;*

1. Introduction

Visual data representations have become an integral part of our daily consumption of information, not only for experts involved in visual analysis, but also for lay audiences through 'casual' data visualizations [PSM07]. Data and visualization literacy, along with data-driven decision-making skills, are therefore essential competencies to participate in a democratic society, as has been stressed by both the European Commission [Eur21] and the OECD, which features data visualization literacy tasks in the reading and mathematics tests of their worldwide PISA study [OEC24]. Previous work has found low levels of data visualization literacy in various general audiences [BMBH16, LKH*16], underscoring the importance of effective data visualization education for the public, beginning at an early age [ARC*17, SGMK24]. While Bach et al. [BKR*24] call for future work exploring diverse (and potentially vulnerable) visualization readers such as children, they also acknowledge the challenges that come with the interdisciplinary nature of teaching visualization.

Teaching data visualization to children and teenagers presents unique circumstances distinct from educating adults. Children and teenagers differ in cognitive development and learning strategies, which are closely tied to age [Che14]. They also typically have less prior knowledge or exposure to data concepts than adults [Khe12], potentially limiting their ability to connect new material to existing knowledge. Usually, children and teenagers are placed in data visualization workshops by parents or teachers, not necessarily due to intrinsic motivation. This might lead to lower initial engagement, requiring tailored approaches to foster curiosity and sustained interest. On the other hand, younger audiences who are still in school typically spend more time actively learning new skills and absorbing information, potentially making them more adaptable to novel topics. These fundamental differences highlight the need for research exploring data visualization education tailored to the unique cognitive, motivational, and developmental needs of children.

However, conducting research with children and underage teenagers is challenging, particularly in terms of participant diversity, recruitment logistics, and experimental design. Since cognitive abilities, learning approaches and background knowledge differ between ages [Khe12], it is difficult to adopt a one-fits-all approach. Grouping participants into narrow age ranges increases the complexity of the study design and might require a larger total sample

DOI: 10.2312/eved.20251025

size. Recruiting children as participants also poses logistical challenges. Unlike adults, they cannot be reached through platforms like crowdsourcing websites or social media. Formal studies require parental consent, and younger participants must often be recruited through schools or community programs, which can result in relatively homogeneous samples.

In addition to these practical and methodological challenges, designing effective data visualization education programs involves a wide range of variables, including the specific focus and guiding themes, the duration and timing of activities, and the balance between instruction and hands-on learning. Each of these factors must be carefully adapted to suit the developmental needs, interests, and attention spans of younger audiences, adding another layer of complexity to the program (and thus study) design. Addressing these challenges is essential for advancing our understanding of how to teach visualization effectively to this critical age group.

We present our experiences from five data visualization workshops for children and teenagers aged seven to sixteen. All were held in Austria over the course of three years in varied contexts, such as summer university courses in different cities and a polytechnical school. Learnings from each workshop were directly used in the development of the subsequent workshops to address the needs, interests, and engagement levels of the participants. While we did not conduct a formal study, we contribute to the growing body of knowledge on data visualization education, thus offering insights into data visualization educational strategies for younger audiences.

Our main contributions are the contextualization of our experiences and the lessons we learned regarding the choice of topics, activity design, and approaches to fostering and keeping up engagement. To help other educators prepare their own data visualization lessons, we also share a GitHub repository containing a selection of our workshop material that will be continuously updated as we conduct further workshops. In the following section, we present previous work in the field and how it has motivated our work. We discuss concrete influences on our approach in Section 3.

2. Related Work

In recent years, a limited but growing body of research has looked at the status quo of data visualization education in schools. For example, Alper et al. [ARC*17] conducted a mixed-methods study conducting an analysis of elementary school textbooks and a survey among teachers. They found that visualizations are heavily used in elementary school material and classrooms and students are thought to interpret and create visualizations in early grades [ARC*17]. Similarly, Boucher et al. [BSK*24] mapped data visualizations in the Austrian and Slovak school systems, both based on interviews with teachers and school books. They identified line, bar, and pie charts as the most important chart types and found that teachers often use storytelling to complement more traditional teaching methods.

Despite the presence of data visualization in school education (materials), Alper et al. [ARC*17] argue that only a small fraction of the curriculum revolves around interpreting or creating data visualizations. The teaching personnel in this study claimed that they think children are not well prepared to create and interpret data visualizations accurately, especially when it comes to critically approaching visualizations. Furthermore, Boucher et al. [BSK*24] reported teachers mentioning not having enough educational material for teaching data visualizations specifically.

More and more research addresses this issue by introducing specific initiatives fostering data visualization literacy in young children and youth. Many of these projects (e.g., [ARC*17, BZP*20, AM22]), however, are centered around specifically developed teaching solutions such as apps and games. Furthermore, they typically employ and test their educational approaches in relatively homogeneous settings, such as in the same school among children with the same educational background. Similary, extensive literature exists on how to design workshops in general (e.g., [BHSW25]), and with a focus on data visualization [KGD*19], but without the focus on children and teenagers. We also took inspiration from Huron et al. [HCBF16] and He and Adar [HA17] who provided ready-to-use material for data visualization education workshops. So far, less research has explored how to design a low-cost data visualization workshop for children that is applicable to a range of different teaching scenarios and target groups and does not require the usage of specific technical solutions.

Our work aims to address this gap by reporting experiences from our own data visualization education workshops that are not tied to a specific technology and cover different age groups from young school children to teenagers.

3. Workshops

We present five data visualization education workshops held by a minimum of three instructors over the course of three years for different age groups, ranging from seven to sixteen, all held in German. Referring to the facets of understanding proposed by Wiggins et al. [WM05], the main goals of the workshops were for the participants to be able to explain the meaning of a given simple chart (*explanation*), relate the information of the chart to previous knowledge (*interpretation*), create own charts with given data (*application*) and, to some extent, critically analyze charts (*perspective*).

Title	Year	Time	Age	Students	Alias
Pilot 1	2022	1 h	7-8	2	Kids
Dear Data	2022	1 h	7-9	15	Kids
Data Influencers 1	2023	1.5 h	14-16	10	Teens
Pilot 2	2023	1 h	7-8	3	Kids
Data Detectives 1	2023	1.5 h	7-9	25	Kids
Data Detectives 2	2024	3 h	9-12	20	Kids
Data Influencers 2	2024	2 h	11-15	16	Teens

Table 1: *Overview of workshops. We roughly split the participants into two categories, "Kids", and "Teens", which we use to reference the respective age groups.*

Table 1 shows an overview of the workshops, including group

sizes and participant ages. Based on their contents (described below), we call the workshops *Dear Data*, *Data Detectives 1 + 2* and *Data Influencers 1 + 2*. While the *Dear Data* and the two *Data Detectives* workshops were aimed at younger age groups (ages 7 to 12, in the following referred to by the alias *kids*), the two *Data Influencers* workshops targeted older children and teenagers (ages 11 to 16, referred to by *teens*). Four of those five workshops (all except *Data Influencers 1*) were organized as stand-alone courses in a summer university program for children in two different locations in Austria (in a rural as well as an urban area), and the *Data Influencers 1* workshop took place at a polytechnical school, a one-year general education school that follows the 8th grade and focuses primarily on career preparation. The age brackets align with the last two developmental stages in Piaget's theory of cognitive development [McI13]. The *kids* fall into the operational stage (7-12 years), where they are capable of logical reasoning and solving problems, as long as they are restricted to concrete scenarios. The *teens* are mostly already in the formal operational stage (12 + years), where abstract thinking and scientific reasoning start to emerge [McI13]. We attempted to align our workshop contents with that theory.

Setup and Limitations. Due to the difficulties of obtaining consent when conducting scientific studies with minors mentioned in the introduction, we avoided collecting any personal data about the participants. Additionally, all workshops were designed with a focus on the participants' learning experience, not with the purpose of a systematic scientific study. We observed, collected feedback as one would do in any workshop and reflected on our experiences but avoided demanding anything from the participants that was for the paper's benefit specifically, not theirs. Participant selection was outside our control, resulting in groups of different age ranges and sizes that were not representative of the respective age groups (such as an all-male group in the *Data Influencers 1* workshop). Beyond the approximate age and, to some extent, the educational level of the participant groups, we did not collect further demographic information from single participants. Even though the workshops *Data Detectives 1* and *2* as well as *Data Influencers 1* and *2* were similar, each of the workshops was only conducted once, with one group of participants. To make the most of the available time slots, the focus was on delivering content rather than providing explicit, detailed feedback at the end of the workshops. While we received valuable feedback from the children and their teachers, two of the workshops were shortened by the hosting institution, which meant that the planned debriefing sessions – where we would have gathered additional participant feedback – could not be conducted.

Synthesis and Validation of Learnings. We build our learnings on three data sources: our own observations (as instructors and observers); feedback from teachers or chaperons who attended the workshops and provided their perspectives in short, informal conversations during and after the workshops; and the participants themselves who were eager to share which parts of the workshops they enjoyed. Immediately after each workshop, we took time together to reflect on our experiences and the reported feedback, taking detailed notes on what went well and what could be improved. In discussion, we then synthesized these experiences into the ten overarching learnings. We validated our workshop design for the *Dear Data* and *Data Detectives* workshops during two pilot workshops with small groups of children we knew and who provided detailed feedback. We validated our learnings by incorporating them into the subsequent workshops and receiving positive feedback. For example, in the *Data Detectives 2* workshop, many participants wanted to take home some more materials, and one chaperoning adult said that our workshop worked better than the session they had chaperoned before. Finally, we also consider the fact that we have been reinvited to conduct our workshops at each venue as positive feedback.

3.1. Themes

Our first workshop, *Dear Data*, was loosely based on the *Dear Data* project [LPP16] and introduced data visualization concepts without a central underlying theme. Based on the experiences with this workshop, we planned the subsequent workshops around concrete topics, aiming to make the data more tangible and relatable.

Climate Crisis. In the *Data Detectives* and *Data Influencers* workshops, we chose the climate crisis as the central theme, recognizing its relevance as a pressing global issue that can be effectively explained and contextualized through data. Research suggests that, despite the complexity of the climate crisis, even elementary school children already show interest in environmental topics [Hol07]. Building on this interest, we introduced fundamental concepts of the climate crisis using a combination of compelling imagery and engaging data visualizations, some of which were sourced from popular social media channels such as @quarks.de, @katapult-magazin, @klima.neutral and @funk. We made the topic more accessible and maintained the students' interest by focusing on age-appropriate and relatable subtopics of the climate crisis, such as the CO_2 emissions of popular foods or electronic devices. This ensured the content was not only educational but also enjoyable. By choosing such a relevant theme, we aimed to stress the usefulness of data visualizations for understanding complex phenomena, while at the same time raising awareness about the climate crisis.

Detective Work. In the *Data Detectives* workshops, we combine the topic of the climate crisis with a story about 'detective work', aiming to engage *kids* in our workshops. This approach allowed us to present climate matters as a coherent story while capturing and maintaining the children's interest and motivation through detective mystery play which has previously [MlAa24] been employed successfully. We humorously introduced ourselves as professional data detectives, solving cases with the help of data evidence, and framed the workshop as a training camp for apprentice detectives. Each child received a data detective ID card to note their most interesting learning of the workshop (*Data Detectives 1*) or collect stamps for completed activities (*Data Detectives 2*), providing a gamified sense of accomplishment and reinforcing motivation.

Social Media. Considering the widespread familiarity and daily relevance of social media in the lives of teenagers [Pew24], social media is an ideal lens through which to explore data visualization. For the *Data Influencers* workshops aimed at teenagers, we therefore introduced social media both as a vehicle to talk about the climate crisis and as a second theme.

We started into the theme by collecting and visualizing the group's social media usage patterns, and continued by discussing

the climate crisis using data visualizations shared on the social media platforms Instagram and TikTok. These real-world examples highlighted how data can be creatively visualized to communicate complex topics to a broad audience. By analyzing and critiquing these visualizations, participants were encouraged to think critically about the effectiveness of such representations and their impact on public understanding. Finally, the participants got a chance to create their own visualizations related to the climate crisis that could be posted on social media in individual hands-on projects.

This integration of social media served multiple purposes: it deepened the participants' engagement by connecting to their lived experiences, demonstrated the ubiquity of charts in their everyday digital interactions, and underscored the power of social media as a tool for raising awareness about pressing global issues like the climate crisis. The theme also allowed for discussions about the credibility and reliability of visualizations encountered online, fostering not only data literacy but also critical media literacy.

3.2. Agenda / Process

The workshops were designed to be highly interactive, encouraging students to actively share their knowledge and interests. Building on experiences from other workshops [BZP*20, BVY*23, AM22], we mixed theoretical input with activities, with a stronger focus on (physical) activity breaks in between theory blocks in younger age groups – due to the potentially beneficial effects for elementary school children [PDV*22]. The agenda components are detailed below; the hands-on projects at the end of each workshop are described in Section 3.3. Figure 1 shows an overview of the total durations and components of the five workshops.

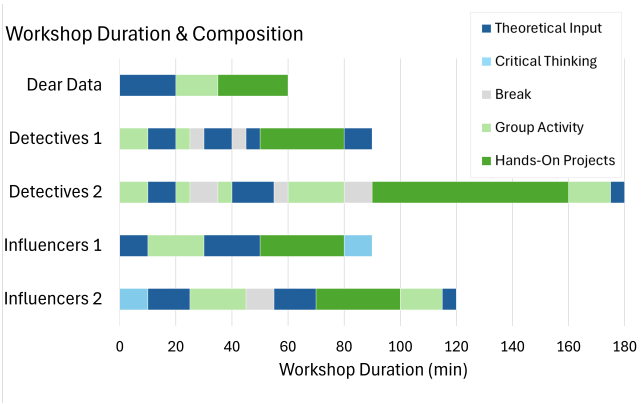

Figure 1: *Composition of the five workshops into five types of content (Theoretical Input, Critical Thinking, Break, Group Activity, Hands-On Projects). Blue segments are presented by the instructors, green segments actively involve the participants.*

Theoretical Input. All five workshops included an introduction to data, data collection, and data visualization early on in the agenda. This introduction served to provide information relevant for subsequent workshop activities and to make the concept of data accessible for children, focusing on the first two facets of understanding, *explanation* and *interpretation* [WM05]. This segment was designed as an interactive lecture, blending information delivery with interaction to both get a sense of the children's prior knowledge and interests and make the session more engaging. We used everyday examples of quantitative and qualitative data and data collection that we expected to be relatable to the respective audience. By grounding such abstract concepts in familiar contexts, our aim was to reduce cognitive barriers.

For the *kids* in the *Data Detectives* and the *Dear Data* workshops, we continued the introduction to data (collection) with an overview of different chart types and, in the *Data Detectives* case, introduced climate change at a later stage of the workshop. In the two *Data Influencers* workshops, we only had a short introduction to data (collection) in general (and, in the case of the *Data Influencers 2* workshop, the concept of data visualization pipelines) and later presented different data visualizations in the context of social media posts about climate change, thus also introducing the workshop's themes. These different approaches aimed to accommodate the differences in previous knowledge between *kids* and *teens*. In accordance with the findings of Boucher et al. [BSK*24] on the prevalence of chart types in school books, we focused on bar charts, line charts, donut charts, and maps in all workshops. While we provided an elementary introduction for the *kids*, we discussed the chart types in the context of real social media posts on climate change with the *teens*.

Critical Thinking. Understanding and creating charts were the primary focus of all workshops. However, considering the social media theme of the *Data Influencers* workshops, we also aimed to foster the *teens'* critical thinking skills in the context of misleading charts. These skills are defined as "the ability to read, interpret, and reason about erroneous or potentially misleading visualizations" [GCK23], aligning with the *perspective* facet of understanding by Wiggins et al. [WM05] and a lack thereof found by Alper et al. [ARC*17]. In the *Data Influencers 1* workshop, we ended with a discussion about a misleading graph [DS21] and how it could be improved to become clearer, e.g., by adapting the axes. In the *Data Influencers 2* workshop, we switched the order and started with a discussion on both misleading graphs and correlation vs. causation before going into the theoretical input section.

Breaks. Considering the *kids'* age and the duration of the workshops (up to 3 hours), we included several breaks and low-effort activities such as a warm-up exercise or distributing detective ID cards to be filled in (*Data Detectives*) between workshop sections.

Group Activities. To facilitate the interaction of the participants with the topic and as an intermediate step between theoretical input and creating their own visualizations [BZP*20], all workshops also included some activities carried out with the entire group at different times. The focus of these activities was both the *interpretation* and *application* facets of understanding [WM05].

The two *Data Detectives* workshops started with a warm-up activity to engage children, encourage interaction, and showcase creative data visualization. For the activity, we asked the children to form groups, first according to their breakfast that morning and then their mode of transportation to get to school. We took photos of the groups for later use and proceeded with the next portion of our workshop. After the first input session from our side (see above), we presented these photos and collected the children's ideas on how to make the number of children per cluster more obvious. We let the

children line up in rows and took another photo which confirmed that personified bar charts were a good choice.

For the *Dear Data* and *Data Influencers* workshops, we took inspiration from Alper et al. [ARC*17]. We collected data from the participants (favorite color, month of birth, social media applications they used, time per day spent on social media) and created visualizations in real-time, using the blackboard for the participants to add their data points directly and Google Sheets as an example of easy-to-use software many students already know from school [BSK*24].

3.3. Hands-on Projects

Building on established practices [ALR22] and prioritizing working with data and data visualizations, we dedicated a substantial portion of each workshop to hands-on visualization activities tailored to specific age groups and conducted in smaller groups (see Figure 2 for impressions). These projects aimed at both the *interpretation* and *application* facets of understanding [WM05].

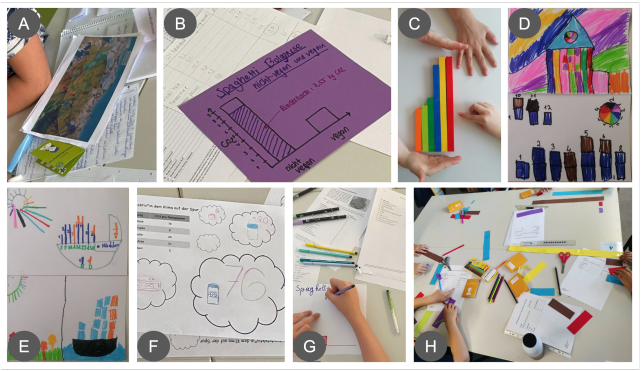

Figure 2: *Impressions of the hands-on projects.*

Dear Data. Inspired by the *Dear Data* project by Lupi et al. [LPP16], we asked the children to draw data collected previously in the workshop, such as favorite colors or months of birth, on postcards (Figure 2 D and E). We collected their addresses, and each child received a randomly selected postcard after the workshop. Beyond the data visualization types discussed previously in the workshop, and some exemplary creative data visualizations both from the *Dear Data* project and drawn by ourselves, the participants did not receive any instructions on how to visualize their data. We did, however, split them into three groups, each of which was closely supervised and consulted by one of us instructors.

Data Detectives. Integrating our learnings from the *Dear Data* workshop, and considering *kids'* difficulties for abstract thinking outside concrete scenarios [McI13], we provided more detailed instructions for the projects for the *Data Detectives* workshops.

For the *Data Detectives 1* workshop, we provided three small climate-related datasets, two of which (CO_2 emissions of food, and CO_2 emissions of different modes of transportation) were visualized by the participants as bar charts using Lego bricks (Figure 2 C) and crafting paper (Figure 2 H), respectively, as has been suggested by other authors [BVY*23, AM22]. The third dataset (CO_2 emissions of different packaging materials) had to be matched with a creative area graph representing differently-sized clouds of CO_2 emissions which the children could then embellish to their taste (Figure 2 F). We split the students into three groups, each of which was supervised by one instructor who worked together with them to translate the dataset into a (physical) visualization. The groups rotated through all three activities.

For the *Data Detectives 2* workshop, we introduced unsolved detective cases inspired by climate mystery stories [EuUdLN] that could be solved using data evidence (Figure 2 A). Each story subtly revealed the climate crisis as the ultimate culprit. The first 'case', which we worked on collectively with the entire class to introduce the concept, involved the unexplained deaths of marmots in the Alps. We solved it using data about rising temperatures and the increasingly harsh living conditions for marmots. We then split the class into three groups (each supervised by one instructor) and had them rotate through three additional cases which they could solve with the help of (drawing and interpreting) data visualizations. These hands-on projects focused less on designing data visualizations, but more on using data and visualizations to make decisions, that is, to solve the case.

One project, for example, involved visualizing temporal data on glacier altitudes in a line chart to work out that the reason for appearing corpses in the mountains is melting glaciers revealing what was previously covered by ice. Another project combined a prepared dataset of rising temperatures with drought data hidden in 'diary entries' to make sense of a boat found in a dry landscape.

Data Influencers. In the *Data Influencers 1* workshop, we provided two datasets (one on CO_2 emissions of different modes of transportation, one on the numbers of public transportation users in their city for several years) to be visualized on paper. Inspired by the approach discussed by Bishop et al. [BZP*20], and considering the *teens'* ability of abstract thinking and scientific reasoning [McI13], we let them choose dataset, chart type, and design elements freely, thus offering minimal instructions while supporting them in their decision-making process. This provided maximum flexibility to adapt to the students' individual needs and offer individual support as needed, thus accommodating the students' different educational backgrounds – some of whom did not speak German as their first language.

Building on this experience, and to further provoke the *teens'* reasoning abilities, we designed a more challenging (end-to-end) data project for the *Data Influencers 2* workshop that involved data preparation steps before the data visualization task. The students could individually choose from two projects we had prepared. In either case, the objective was to visualize the data in the design of an Instagram post. This aimed to motivate students to get creative and think about colors, embellishments, and their audience.

One project involved calculating and visualizing the CO_2 emissions of a recipe of their choice. We provided a set of recipes as well as data regarding the CO_2 emissions of many foods. The students then had to calculate the CO_2 emissions for the required amount of each ingredient in their recipe, before visualizing this data (Figure 2 B and G). The other project dealt with the environmental factors of travel. We again provided the data regarding the emissions of various modes of transportation, as well as an exemplary trip and

various options how this trip can be completed (e.g., going by train, using the car to get to an airport and then flying, combining car and trains, etc.). The students then had to calculate the total emissions for a few travel options and visualize those in their preferred way.

4. Learnings

We present key learnings from our five workshops, which we believe can benefit other educators. These learnings apply to all age groups we worked with and some of them align with what was found to be relevant in other workshops [KGD*19, BHSW25]. Where suitable, we provide insights into age-specific experiences in detail. While our findings do not stem from a formal study and are therefore not generalizable, they provide insights into several questions raised in "Challenges and Opportunities in Data Visualization Education: A Call to Action" by Bach et al. [BKR*24]. To contribute to this discussion, we mapped our key learnings (numbered LX) to corresponding questions (denoted QX) from Bach et al. [BKR*24]. Figure 3 illustrates how our learnings relate to the categories of questions they present. A full list of questions and respective learnings is available in our GitHub repository (https://github.com/DataVisEd/Data-Visualization-Workshops).

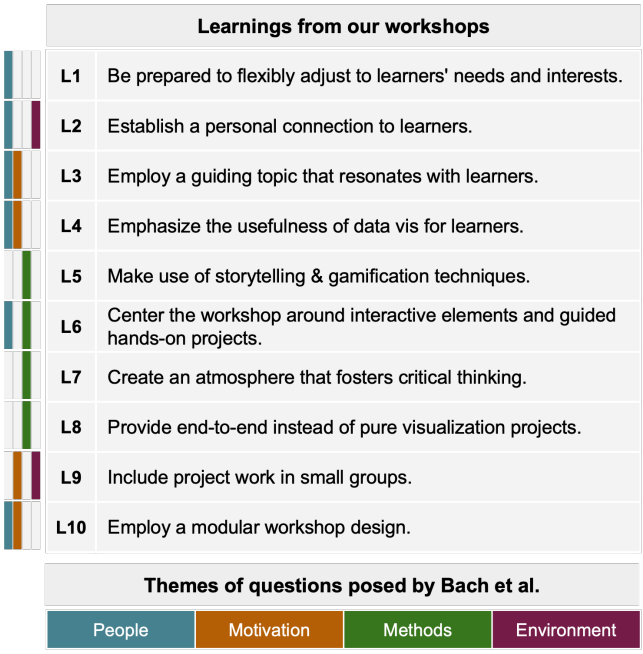

Figure 3: *Learnings from our workshops and corresponding themes of addressed questions posed by Bach et al. [BKR*24].*

L1: Be prepared to flexibly adapt to learners' needs and interests (Q3). Given the setup of our workshops across different institutions with children from various schools and classes, our participant pool was likely more diverse than in a typical school setting. We worked with participants of varying ages, socio-economic and educational backgrounds, and language proficiencies. This diversity came with unpredictable differences in development (especially noticeable among the *kids*), prior knowledge, comprehension, learning preferences, and engagement. Many of these circumstances were beyond our control and only partially known in advance; the *Data Influencers 2* workshop, for example, had participants mainly from the lower end of the announced age range, i.e., at the brink of the formal operational stage [McI13]. As a result, some of the *teens* solved the hands-on project as intended, while others were still somewhat overwhelmed by the level of abstraction needed. Balancing content and activities to engage advanced participants without overwhelming others proved challenging. We succeeded by employing activities with individually scalable complexity, adapting content on the fly, encouraging low-pressure participation, and providing individualized support. This flexible and responsive approach to meet diverse needs [KC15] was possible thanks to at least three instructors per workshop. L1 aligns with Kerzner et al. [KGD*19] who recommend to "adapt [workshop methods] tactically" even when dealing with adult and more homogenous audiences.

L2: Establish a personal connection to learners (Q6, Q28). Since all workshops took place outside of regular school activities, the participants did not know us beforehand. Establishing a personal connection proved beneficial in fostering engagement and building learners' confidence. In the *Data Influencers* workshops, we gained the *teens'* acceptance and encouraged participation by sharing our own experiences with social media. Engagement grew further when students realized that one of us was part of a sports club they recognized. *Kids* responded positively when we directly encouraged them or shared personal anecdotes during the activities.

To facilitate these personal interactions, we divided participants into smaller groups and maintained a high instructor-to-learner ratio, which allowed for more individualized attention. Our approach aimed to keep the workshops collaborative by fostering interaction both among participants and between participants and us instructors. Additionally, the absence of formal assessments reduced performance pressure, enabling students to participate without fear of making mistakes. As external instructors, we were also able to interact more informally with the learners, minimizing hierarchical barriers and promoting a more open, engaging environment.

L3: Employ a guiding topic that resonates with learners (Q6, Q17, Q19). Reflecting on the *Dear Data* compared to the subsequent workshops, selecting a guiding topic that resonates with learners' interests and experiences proved helpful in enhancing engagement and understanding among participants. It also enabled us to find a common ground between participants with various backgrounds. In the workshops with *kids* (*Data Detectives*), we simplified the concept of the climate crisis by focusing on relatable aspects, such as familiar foods or modes of transportation. Framing the activity as a detective mission to find the 'villain' named climate change kept them motivated. For the *teens* (*Data Influencers*), we analyzed climate-related charts shared on social media and selected topics like CO_2 emissions from electronic devices to align with their interests. These approaches successfully sparked meaningful discussions and kept participants engaged. However, we did notice somewhat reduced interest in the topic of social media with the younger *teens* in the *Data Influencers 2* workshop, highlighting the importance of age-specific topics.

In both the *Data Detectives 1* and the *Data Influencers 1* work-

shop we designed the hands-on project by first selecting a mode of visualization (drawing, Lego bricks, crafting paper) and then fitting a task related to the guiding topic to it, resulting in a somewhat disjoint narrative. In the subsequent workshops, however, we reversed the process by first deciding on tasks related to the guiding topic (solve a case, create a visualization for social media) and then finding suitable visualizations, leading to a more coherent, creative, and engaging workshop design.

L4: Emphasize the usefulness of data vis for learners (Q6, Q17). By engaging students in collecting and visualizing data about familiar aspects of their lives, such as social media use, we demonstrated how data visualization can help make sense of personal information. Since students were already familiar with metrics like the number of accounts they followed or the time spent on specific apps, they quickly saw how visualizations could help them compare results and gain new insights. This hands-on experience underscored data visualization's practical utility as a tool for interpretation and communication. Additionally, by introducing free and easy-to-access tools for creating visualizations, such as Google Sheets, we enabled participants to explore other use cases, such as visualizing the development of their pocket money over time. Hence, we recommend engaging in conversations with learners about their interests and passions, while emphasizing how data visualizations can be applied in contexts relevant to their lives.

L5: Make use of storytelling & gamification techniques (Q22). All five workshops included both storytelling and gamification elements, albeit to different extents. Gamification has been defined as "the use of game design elements in non-game context" [DDKN11] and recent years have brought a lot of discussion on the use of gamification in educational contexts. However, many of these studies refer to computer-based material [NBC*19] and there is little literature on how to use gamification in an in-person classroom setting.

The power of storytelling and gamification was most apparent in the *Data Detectives* workshops. Both of them framed the *kids* as *data detectives in training* but only the *Data Detectives 2* workshop told a coherent story from beginning to end. In the *Data Detectives 1* workshop we did not integrate the *data detective ID cards* into the activities enough and while the *kids* were excited for a souvenir to take home and handing out the ID cards was useful as a short break in a longer theoretical session, ultimately the ID cards did not have a clear purpose in the context of the workshop. We also designed the hands-on projects with a focus on the data visualization and data physicalization aspects, leading to somewhat uninspired detective stories. In the *Data Detectives 2* workshop, on the other hand, we prioritized the *detective* component of the workshop and designed all our material around this theme, which resulted in a much more coherent overall workshop design. The stamps they could collect for each finished activity motivated the *kids* so much that they even asked to bring home some of their unfinished work. Also, the final projects themselves were embedded in a story as each project was a case the detectives had to solve using data visualizations. This had a visible impact on the *kids'* motivation and engagement and they were excited by the thought of working as detectives and solving cases with data.

In the *Data Influencers* workshops, we did not have any explicit gamification elements. We specifically decided not to focus on the competitive aspect of social media and, for example, did not collect any data on the number of followers the *teens* had on their social media accounts to avoid the potential negative effects of teenage group dynamics. When collecting data about the *teens'* social media use, however, we noticed an interest in comparing screen time or the number of apps used between the *teens*. Designing parts of the workshop as a competition, for example between two teams of participants, could increase engagement. In contrast to the *Data Influencers 1* workshop, which only involved storytelling in the context of social media, the final projects in the *Data Influencers 2* workshop were centered around questions such as "Which recipe has the lowest CO_2 emissions" or "Which mode of transportation has the lowest CO_2 emissions?". While adding complexity to the projects, we noticed this also made the visualization tasks more interesting to the *teens*.

L6: Center the workshop around interactive elements and guided hands-on projects (Q9, Q22). The high degree of interactivity in all workshop components, even in the theoretical input segments, allowed us to partially adapt content and speed to the students' knowledge and interests. We also found that interactivity allowed the students to learn from each other. The participants of the *Data Detectives* workshops were intrigued by the idea of acting as climate detectives or experts themselves and showed a high level of involvement and excitement, happily volunteering their previous knowledge and ideas. We specifically noticed the difference interactivity can make for student engagement in comparison of the *Data Influencers* and the *Data Detectives* workshops. The participants of the first ones, which we started with the background on data and data visualizations, took much longer to show interest and begin interacting with us than those in the second workshops, where we started with a physical activity. However, this could also have been due to age-related differences in engagement between *kids* and *teens*.

The hands-on projects generally were well received, even considering that many students needed some guidance and detailed explanations. While not all students were able to solve the tasks the way we had imagined, all of them got creative with visualizing the data, and most of them proudly wanted to take their results home. Across all workshops, we noticed that regardless of age the students were more engaged in these activities when given some guidance on how to visualize their specific data, for example in the form of material tailored to a specific type of visualization (*Data Detectives 1*) or a template to fill out (*Data Detectives 2*).

For most interactive workshop components, but in particular for the hands-on projects, we had calculated barely enough or too little time, underestimating how small delays quickly add up in a larger group. As shown in Figure 1, we adapted our workshop design by increasing the time spent on activities and projects, while keeping the theoretical input sections nearly constant.

L7: Create an atmosphere that fosters critical thinking (Q24). In both *Data Detectives* workshops we were pleasantly surprised by the amount of critical thinking demonstrated during both the climate discussions and the detective work, aligning with findings that already elementary school children have the ability to critically assess concepts [Lai11]. We now believe the *kids* would have been eager to identify misleading visualizations and plan to include

it in future workshops, especially considering the fact that critical assessment of data visualizations is not prioritized in elementary school education [ARC*17].

With the *social media* theme of the workshop and the age of our participants in mind, we included a segment dedicated to the critical assessment of data visualizations specifically at the end of the *Data Influencers 1* workshop. We aimed to encourage critical assessment of data visualizations and provide the relevant skills as well as to remind the students not to 'believe everything they see on the internet'. While the *teens* were very susceptible to the idea of misleading graphs, quickly identified deceptive visualizations, and were open to discussing possible explanations and potential improvements, they seemed even more interested in the content of our example visualization [DS21], namely why it only depicted women.

To catch the *teens'* interest we switched the order in the *Data Influencers 2* workshop and started with the critical thinking section. However, the discussion was not as lively as in the previous workshop, maybe due to the (unexpectedly) lower age of the participants or because, at the beginning of the workshop, they did not feel confident enough to offer critical opinions. Especially the topic of correlation and causation did not resonate with them. In future workshops, we therefore plan to first create an atmosphere in which critical thinking is encouraged before going into the critical assessment of data visualizations and tailoring the critical thinking content even more to the participants' age.

L8: Provide end-to-end instead of pure visualization projects (Q24). Data visualization cannot be seen as an individual task, as it is closely tied to data preparation. Both for interpreting data visualizations one encounters in the media and for creating own visualization, it is important to understand data sources and data structures. While our introduction to data analysis pipelines in the *Data Influencers 2* workshop seemed to be a bit too complex for the participants' age, we found that adding some data preparation tasks in the final projects of the workshop made the tasks more challenging and interesting compared to the *Data Influencers 1* workshop where the data were provided in their final form and some *teens* were clearly bored by the simplicity of the task. We also saw this effect in the group activities where data were collected and visualized collectively, making them more tangible.

L9: Include project work in small groups (Q20, Q27). The individual hands-on projects in the *Dear Data*, *Data Detectives 1* and *Data Influencers 1* workshops did not stimulate much interaction between the participants, contrasting the experiences by Bishop et al. [BZP*20] who reported their participants "learned from shared experiences". While some participants were quick to figure out the task at hand, worked independently and got very creative during those activities, others followed our instructions very closely and regularly asked for next steps. Having them work together in a smaller group, as we did in the *Data Detectives 2* and the *Data Influencers 2* workshops, helped get everyone on board.

Splitting the participants into balanced groups in terms of skills, needs, and temperaments combined with close supervision by and interaction with us instructors made sure everyone was heard, mitigating the problem of a few participants dominating the scene while others stay quiet. We observed that quieter participants became more talkative and engaged than during the other workshop parts. The smaller groups also allowed us to tailor our input and support to individual participants' needs, more than it had been possible when working with the entire group. The resulting smaller teacher-student ratio also reduced our individual workloads.

L10: Employ a modular workshop design (Q3, Q20). Before and during all five workshops we had to spontaneously adapt to changes in participant age, participant number, and workshop duration. The *Data Influencers 2* workshop, for example, had participants from the lower end of the announced age range only which we were told on the day of the workshop. Both *Data Influencers* workshops were unexpectedly cut short, which we were informed of during the workshops. Some of the workshop segments, especially the hands-on projects in the *Dear Data* and *Data Detectives* workshops took longer than expected, while others led to discussions different from our expectations. Considering our already prepared workshop material, our flexibility was limited but we did our best, for example, by spontaneously cutting more complex projects and reducing the number of activities. A modular workshop design that allows to easily add or remove individual segments while maintaining a coherent workshop can help provide more flexibility, which is also recommended by Kerzner et al. [KGD*19]. Additionally, such a modular workshop would allow to conduct various versions of the same workshop, reducing the workload in preparation.

5. Conclusion

We present our learnings from five data visualization education workshops with children and teenagers and relate them to the call to action by Bach et al. [BKR*24]. Key observations include the importance of tailoring content to developmental stages, using storytelling and gamification to sustain interest, and fostering collaboration through activities in small groups. We also found that a personal connection to both the topic and the workshop instructors increases participant engagement. By reflecting on our hands-on experiences with designing and conducting these workshops, we aim to help other educators plan their workshops and inspire future studies looking into specific aspects of data visualization education workshop design; one such aspect could be the importance of emphasizing the usefulness of data visualization for participant motivation. Moreover, we provide the materials used in the most recent iteration of the workshops for both age groups in our GitHub repository (https://github.com/DataVisEd/Data-Visualization-Workshops).

References

[ALR22] ADAR E., LEE-ROBBINS E.: Roboviz: A game-centered project for information visualization education. *IEEE Transactions on Visualization and Computer Graphics 29*, 1 (2022), 268–277. doi:10.1109/TVCG.2022.3209402. 5

[AM22] AMBROSINI L., MEYER M.: Data bricks space mission: Teaching kids about data with physicalization. In *2022 IEEE Workshop on Visualization for Social Good (VIS4Good)* (2022), pp. 10–14. doi:10.1109/VIS4Good57762.2022.00007. 2, 4, 5

[ARC*17] ALPER B., RICHE N. H., CHEVALIER F., BOY J., SEZGIN M.: Visualization literacy at elementary school. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2017), CHI '17, Association for Computing Machinery, pp. 5485–5497. doi:10.1145/3025453.3025877. 1, 2, 4, 5, 8

[BHSW25] BROOKS-HARRIS J., STOCK-WARD S.: *Workshops: Designing and facilitating experiential learning*. SAGE Publications, Inc., Thousand Oaks, California, 2025. doi:10.4135/9781452204864. 2, 6

[BKR*24] BACH B., KECK M., RAJABIYAZDI F., LOSEV T., MEIRELLES I., DYKES J., LARAMEE R. S., ALKADI M., STOIBER C., HURON S., PERIN C., MORAIS L., AIGNER W., KOSMINSKY D., BOUCHER M., KNUDSEN S., MANATAKI A., AERTS J., HINRICHS U., ROBERTS J. C., CARPENDALE S.: Challenges and opportunities in data visualization education: A call to action. *IEEE Transactions on Visualization and Computer Graphics 30*, 1 (2024), 649–660. doi:10.1109/TVCG.2023.3327378. 1, 6, 8

[BMBH16] BÖRNER K., MALTESE A., BALLIET R. N., HEIMLICH J.: Investigating aspects of data visualization literacy using 20 information visualizations and 273 science museum visitors. *Information Visualization 15*, 3 (2016), 198–213. doi:10.1177/1473871615594652. 1

[BSK*24] BOUCHER M., STOIBER C., KEJSTOVA M., KANDLHOFER M., ERTL A., KRIGLSTEIN S., AIGNER W.: Mapping the landscape of data visualizations in schools and educational resources. *EuroVis 2024 - Education Papers* (2024). doi:10.2312/EVED.20241052. 2, 4, 5

[BVY*23] BAE S. S., VANUKURU R., YANG R., GYORY P., ZHOU R., DO E. Y.-L., SZAFIR D. A.: Cultivating visualization literacy for children through curiosity and play. *IEEE Transactions on Visualization and Computer Graphics 29*, 1 (2023), 257–267. doi:10.1109/TVCG.2022.3209442. 4, 5

[BZP*20] BISHOP F., ZAGERMANN J., PFEIL U., SANDERSON G., REITERER H., HINRICHS U.: Construct-A-Vis: Exploring the free-form visualization processes of children. *IEEE Transactions on Visualization and Computer Graphics 26*, 1 (2020), 451–460. doi:10.1109/TVCG.2019.2934804. 2, 4, 5, 8

[Che14] CHEN M.-L.: Age differences in the use of language learning strategies. *English Language Teaching 7*, 2 (2014). doi:10.5539/elt.v7n2p144. 1

[DDKN11] DETERDING S., DIXON D., KHALED R., NACKE L.: From game design elements to gamefulness: Defining "gamification". In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments.* (Tampere, Finland, 2011), pp. 9–15. doi:10.1145/2181037.2181040. 7

[DS21] DICKS A., SCHOCH K.: Summer workshop series provides training in science communication. Figure 2. https://inprintscience.wustl.edu/summer-workshop-series-by-inprint/, 2021. Accessed: 2024-12-10. 4, 8

[Eur21] EUROPEAN COMMISSION: Digital education action plan. https://education.ec.europa.eu/focus-topics/digital-education/action-plan, 2021. Accessed: 2024-12-10. 1

[EuUdLN] ENERGIE-UND UMWELTAGENTUR DES LANDES NÖ: Mit den Black-Klima-Stories den Klimawandel durchschauen. https://www.umwelt-bildung.at/mit-den-. Accessed: 2024-12-10. 5

[GCK23] GE L. W., CUI Y., KAY M.: Calvi: Critical thinking assessment for literacy in visualizations. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2023), CHI '23, Association for Computing Machinery. doi:10.1145/3544548.3581406. 4

[HA17] HE S., ADAR E.: VizItCards: A card-based toolkit for infovis design education. *IEEE Transactions on Visualization and Computer Graphics 23*, 1 (2017), 561–570. doi:10.1109/TVCG.2016.2599338. 2

[HCBF16] HURON S., CARPENDALE S., BOY J., FEKETE J.-D.: Using VisKit: A manual for running a constructive visualization workshop. *Pedagogy of Data Visualization Workshop at IEEE VIS 2016* (2016). 2

[Hol07] HOLDEN C.: Children as citizens: An international perspective. In *Citizenship Education in Society* (2007), London: CiCe, pp. 13–20. 3

[KC15] KOC N., CELIK B.: The impact of number of students per teacher on student achievement. *Procedia - Social and Behavioral Sciences 177* (2015), 65–70. doi:10.1016/j.sbspro.2015.02.335. 6

[KGD*19] KERZNER E., GOODWIN S., DYKES J., JONES S., MEYER M.: A framework for creative visualization-opportunities workshops. *IEEE Transactions on Visualization and Computer Graphics 25*, 1 (2019), 748–758. doi:10.1109/TVCG.2018.2865241. 2, 6, 8

[Khe12] KHEZRLOU S.: The relationship between cognitive and metacognitive strategies, age, and level of education. *The Reading Matrix 12*, 1 (2012). 1

[Lai11] LAI E. R.: Critical thinking: A literature review. *Pearson's Research Reports 6*, 1 (2011), 40–41. 7

[LKH*16] LEE S., KIM S.-H., HUNG Y.-H., LAM H., KANG Y.-A., YI J. S.: How do people make sense of unfamiliar visualizations?: A grounded model of novice's information visualization sensemaking. *IEEE Transactions on Visualization and Computer Graphics 22*, 1 (2016), 499–508. doi:10.1109/TVCG.2015.2467195. 1

[LPP16] LUPI G., POSAVEC S., POPOVA M.: *Dear data*. Penguin Particular Books, New York City, 2016. URL: http://www.dear-data.com/. 3, 5

[McI13] MCINERNEY D. M.: *Educational psychology: Constructing learning*. Pearson Higher Education AU, 2013. 3, 5, 6

[MlAa24] MARTINEZ-LEJARRETA L., ARNOTT L., AND K. W.: Detective mystery play: Play-based research methods for facilitating young children's critical thinking. *International Journal of Early Years Education 32*, 4 (2024), 871–884. doi:10.1080/09669760.2024.2407471. 3

[NBC*19] NAND K., BAGHAEI N., CASEY J., BARMADA B., MEHDIPOUR F., LIANG H.-N.: Engaging children with educational content via gamification. *Smart Learning Environments 6*, 1 (2019), 6. doi:10.1186/s40561-019-0085-2. 7

[OEC24] OECD: PISA test. https://www.oecd.org/en/about/programmes/pisa/pisa-test.html, 2024. Accessed: 2024-12-19. 1

[PDV*22] PEIRIS D. L. I. H. K., DUAN Y., VANDELANOTTE C., LIANG W., YANG M., BAKER J. S.: Effects of in-classroom physical activity breaks on children's academic performance, cognition, health behaviours and health outcomes: A systematic review and meta-analysis of randomised controlled trials. *International Journal of Environmental Research and Public Health 19*, 15 (2022). doi:10.3390/ijerph19159479. 4

[Pew24] PEW RESEARCH CENTER: Teens, social media and technology 2024. https://www.pewresearch.org/internet/2024/12/12/teens-social-media-and-technology-2024/, Dec. 2024. Accessed: 2025-03-20. 3

[PSM07] POUSMAN Z., STASKO J., MATEAS M.: Casual information visualization: Depictions of data in everyday life. *IEEE Transactions on Visualization and Computer Graphics 13*, 6 (2007), 1145–1152. doi:10.1109/TVCG.2007.70541. 1

[SGMK24] SCHUSTER R., GREGORY K., MÖLLER T., KOESTEN L.: "Being simple on complex issues" — Accounts on visual data communication about climate change. *IEEE Transactions on Visualization and Computer Graphics* (2024), 1–13. doi:10.1109/TVCG.2024.3352282. 1

[WM05] WIGGINS G. P., MCTIGHE J.: *Understanding by design*, expanded 2nd ed. Association for Supervision and Curriculum Development, Alexandria, VA, 2005. 2, 4, 5