The Comic Construction Kit: An Activity for Students to Learn and Explain Data Visualizations

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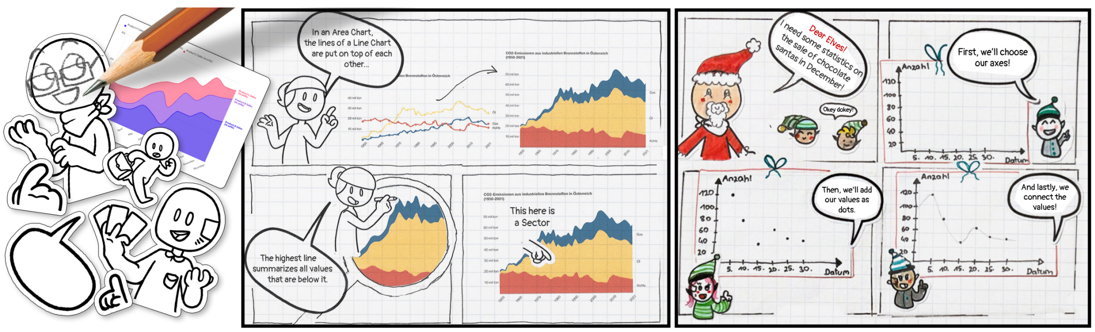

Figure 1: Using our Comic Construction Kit, students engage in a hands-on activity, exploring various data visualizations by creating explanatory comics. Students can affix stickers onto graphs, annotate them, or augment them with additional elements. Shown here are two excerpts from a high school student's (left) and a bachelor student's (right) comics, who creatively used the materials to e.g., create a magnifying glass effect by cutting out a printed graph, or transforming a blank character sticker into Santa.

Abstract

As visualization literacy and its implications gain prominence, we need effective methods to prepare students for the variety of visualizations in an increasingly data-driven world. Recently, the potential of comics has been recognized in various data visualization contexts, including educational settings. We describe the development of a workshop in which we use our "comic construction kit" as a tool for students to understand various data visualization techniques through an interactive creative approach of creating explanatory comics. We report on our insights from holding eight workshops with high school students and teachers, university students, and lecturers, aiming to enhance the landscape of hands-on visualization activities that can enrich the visualization classroom. The comic construction kit and all supplemental materials are open source under a CC-BY license and available at https://fhstp.github.io/comixplain/vis4schools.html.

Index Terms: data comics, storytelling, visualization education, visualization literacy, visualization activities

1 Introduction

As the world becomes increasingly data-driven, the ability to comprehend and interpret various data visualizations is becoming crucial. Hence, visualization literacy [6, 9, 5] is emerging as an essential skill across disciplines. The visualization community has recently recognized this importance with a IEEE CG&A special issue [2], panel discussions [1], a dedicated Dagstuhl Seminar [17] and multiple workshops on visualization education and activities [18, 21]. Concurrently with these developments, numerous researchers have called for activities that support students' learning processes [26]. The complex and interdisciplinary nature of visualization creates many challenges in teaching diverse audiences. Hence, researchers highlight the importance of hands-on, interactive experiences, and incorporating creativity and playfulness in learning environments [3].

Comics have been extensively validated as effective learning aids for both children and adolescents [22] and adults [31] in various subjects from English [19] to Science [24] or Programming [30]. Therefore, we further explore the medium as an educational tool for data visualization. Comics' efficacy stems not only from their lower cognitive load and approachability but also from their nature as a sequential art form, which facilitates easily digestible step-by-step explanations [13]. They can also feature character-driven narratives that promote self-reflection [14]. In the context of data visualization, comics have demonstrated their versatility in the form of data comics [4], which transform data insights into visually engaging, data-driven narratives. They are also used in data visualization cheat sheets [33] to help users understand the usage, anatomy, and common pitfalls of various visualization techniques, presenting information in a novice-friendly manner that also serves as a quick reference for more intermediate practitioners.

Now, comics can transcend their traditional role as a passive medium crafted by experts for learners to become an active tool in education. For example, Wang et al. [32] use data comic design workshops in which students learn data-driven storytelling by creating data comics, which has been well-received. Given that data comics typically focus on conveying insights through visualizations rather than explaining the visualizations themselves, though, we hypothesized that learners could also greatly benefit from creating comics that adopt a more explanatory approach [7]. By actively transforming their newly acquired knowledge of various chart types into narrative, explanatory formats, learners would be likely to enhance their retention of the information. This method mirrors the effective "learning-by-teaching" strategy [23].

The workshop described in this paper is designed to be used in visualization related classes or lectures, specifically in the context of different chart types and their purposes. Given the wide variety of visual representations, effectively teaching the "visualization zoo" [16] is a significant challenge in visualization educa-

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tion [3]. Recognizing the value of creative learning activities in this field [26], our workshop is designed to reinforce theoretical knowledge from lectures, providing students an opportunity to engage deeply with a specific visualization technique and fostering group learning, creativity, and self-expression.

In this paper, we present and reflect on our workshop's setup and results, and introduce its central component: the "comic construction kit". Our main contributions are: 1) a free-to-use comic construction kit (presented in Section 2) with customizable materials to reproduce our workshop; 2) the design of the workshop, as described in Section 3; and 3) a discussion of our experiences with the format in Section 5.

2 The Comic Construction Kit

A common obstacle encountered in several previous workshops and lectures was participants' hesitance to engage in drawing activities, often citing their lack of drawing skills. A similar issue is also described by Wang et al. [32] in their data comic workshops, where even students of art-related subjects felt overwhelmed by the variety of design options available to them. We found that introducing templates and drawing references significantly lowered the participation barrier in our courses. For the new workshops, we hence developed what we named the "comic construction kit". This kit comprises two A4 pages with a 3x3 comic panel grid offering flexibility in panel sizes by drawing over it, a selection of printed example data visualizations in various sizes (such as line charts, stacked area charts, and stream graphs, depending on the learning goals) along with respective cheat sheets, and two A4 pages of stickers. These stickers, featuring comic characters in various poses and speech bubbles, are printed on writable label paper using a regular inkjet printer, and are die-cut with a cutting machine (see Figure 1). The comic grids and character designs are derived from the Comixplain repository [10]. They are easily customizable and allow making additions such as drawing a character a hat or coloring them. The use of stickers was motivated by research advocating for playful methods and active learning [25, 15], which promote curiosity, motivation, experimentation, and enjoyment [11, 29, 20].

3 Workshops

We conducted a total of eight instances of the workshop between October 2023 and January 2024. In total, 105 people produced 40 comic samples (see Table 1). All workshops lasted between 80 and 100 minutes, followed the same base structure, and were centered around using the comic construction kit to create explanatory comics. However, we tailored the topic introductions, the contents of the kits, and the post-creation activities to suit the specific target group and their learning objectives. This led to two slight variations of the workshop format, which we call A and B (see Figure 2).

3.1 Workshop A

Workshop Version A, used in the first six workshops W1-W6 (see Table 1 and Figure 2), introduced participants to one or more specific chart types they were then tasked to explain in their comics.

3.1.1 Workshop Setting

This version targeted groups without a specialized focus or limited knowledge of visualization topics. Recognizing the importance of bringing data visualization to schools [8], we chose middle and high school teachers as well as students as our target group. We conducted a pilot workshop (**W1**) with visualization researchers and lecturers to gather feedback from domain experts, however, no substantial changes were made afterwards. The workshops were structured as follows:

1) Introduction (10-20 minutes): We started by introducing the participants to specific chart types in a lecture format using PowerPoint slides. The content was adapted based on the participants' ex-

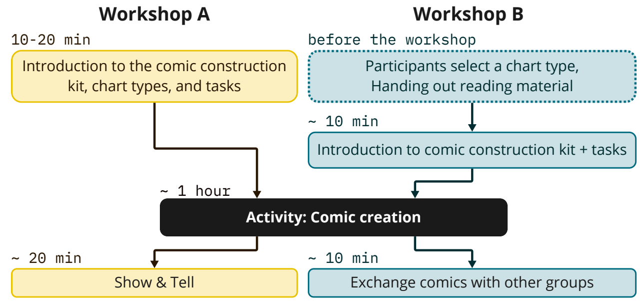

Figure 2: Overview of our workshop procedure with the comic creation process as the core activity. Variation A and B differ slightly in pre- and post-tasks to accommodate different contexts.

isting knowledge and skills, either focusing on a single chart type or comparing two similar types to facilitate learning by analogy [27]. Then, we introduced how to use the comic construction kit (see Section 2. In this variation of the workshop (A), the learning goal was to understand the differences between line charts, area charts, and stream graphs, which are well-suited for learning by analogy.

2) Comic creation (60 minutes): In the second phase of the workshop, we encouraged the participants to craft their own explanatory comics about the chart types discussed earlier. Participants formed groups of two or three to promote creative collaboration. They manipulated the printed example graphs using scissors and glue, sometimes even cutting out specific elements to highlight particular features, such as drawing a magnifying glass to emphasize a part of a chart (see Figure 1). They used and customized the stickers to create an overarching narrative or dialogue between characters. To ensure the correctness of their explanations, students could consult the provided cheat sheets, and workshop facilitators were available to answer any questions.

3) Show & Tell (around 20 minutes): At the end of the workshop, each group briefly presented their comics, explaining their narratives and the rationale behind specific choices they made. We used a mobile phone camera to cast live footage to a projector in the room, enabling all participants to see the comics. This setup also allowed the presenting group to move the camera closer to specific parts of their comics while the other groups could remain seated.

All workshops of type A (W1-W6) used the same materials, although we made minor *adjustments* to accommodate the varying ages and educational levels of the participants (see Section 3.1.2). For instance, in **W4**, we limited the chart types to line charts alone to prevent overwhelming the middle school students with too many new concepts within the brief workshop duration. For the high school students in **W5**, we incorporated both line- and area charts but omitted stream graphs, whereas the other workshops included all three chart types. The differences between the workshop instances are listed in Table 1.

3.1.2 Participants

After the pilot workshop **W1** with five visualization researchers and lecturers (3 male, 2 female), **W2** and **W3** included middle- and high school teachers (6 male, 5 female) at various career stages, from newcomers to retirees, with teaching experience ranging between 3 and 40 years (M: 19.4, SD: 14.4). On a 5-point Likert scale, they rated their experience with data visualizations mostly high (1 ▁■■■ 5, Median: 4), but their comic creation experience as limited (1 ■▁▁▁ 5, Median: 1), although half of them stated to already have used comics as material in their classes.

W4 was conducted with middle school students aged 14 years (3 male, 8 female). They were asked to rate statements on a 5-point Likert scale, ordered from 1 - Strongly Disagree to 5 - Strongly Agree: (1) *I regularly read comics or manga* (1 ■▬▁ ■ 5, Median:

Table 1: Overview of workshop details, listing the participant groups, locations, focused chart types, and the number of comics produced in each workshop. In total, 105 participants created 40 comics. For the difference between workshop type A and B, see Figure 2.

ID	Type	Participants	Location	Charts	Comics
W1	A	DataVis Researchers & Lecturers (5)	Research Retreat (Pilot)	Line Chart, Area Chart, Stream Graph	2
W2	A	Middle- & High School Teachers (8)	Event by the Austrian Federal Ministry of Education	Line Chart, Area Chart, Stream Graph	3
W3	A	Middle- & High School Teachers (3)	Austrian Education Conference	Line Chart, Area Chart, Stream Graph	3
W4	A	Middle School Students (11)	Middle School, Vienna, Austria	Line Chart	4
W5	A	High School Students (28)	High School, Lower Austria	Line Chart, Area Chart	8
W6	A	University Students, Bachelor (21)	DataVis Course, UAS Upper Austria	Line Chart, Area Chart, Stream Graph	7
W7	B	University Students, Master (17)	DataVis Course, UAS Upper Austria	Radar- & Line Chart, Choropleth- & Density Map, Dotplot, Parallel Sets	7
W8	B	University Students, Bachelor (12)	DataVis Course, UAS Upper Austria	Area-, Pie- & Line Chart, Treemap, Choropleth Map, Histogram	6

2). (2) *I have created own comics* (1 5, Median: 2). (3) *My teachers have used comics in class before* (1 5, Median: 2). (4) *I have created diagrams before* (1 5, Median: 4). (5) *I find it easy to read diagrams* (1 5, Median: 4).

The high school students in **W5** (all 28 female) were aged 18-19 years. We asked them to rate the same statements as the students in W4: *I regularly read comics or manga* (1 5, Median: 1). (2) *I have created own comics* (1 5, Median: 2.5). (3) *My teachers have used comics in class before* (1 5, Median: 3). (4) *I have created diagrams before* (1 5, Median: 4). (5) *I find it easy to read diagrams* (1 5, Median: 3).

To test whether the activity could also be effectively integrated into university courses, **W6** was conducted with a group of bachelor students (13 female, 8 male) enrolled in a digital product design program within a visualization course. The students, with a mean age of 23.8 years (SD: 4.95), had already been introduced to the basics of data visualization but had not explored various chart types. At the start of the workshop, students rated their comic experience on a 5-point Likert scale from 1 = “limited experience” to 5 = “extensive experience” (1 5, Median: 2).

3.2 Workshop B

Workshop Version B was used in W7-W8 (see Table 1 and Figure 2) and differed from Version A in that students researched their own chart types to cover in the comics in advance.

3.2.1 Workshop Setting

While the implementation of Workshop A in a university setting (W6) was successful, we found that it did not fully use the potential to cover a broader range of chart types from the “visualization zoo” and was insufficiently integrated into the whole course concept. Consequently, we conducted **W7** and **W8** in two different data visualization courses. The course of W7 emphasized project-based learning, with the ultimate goal for students to analyze and create an interactive dashboard using their own dataset in groups of two to three. W8 was conducted in a similar course like W6.

To better align with the course structures, we modified the pre- and post-comic creation tasks, as seen in Figure 2. *Before* the workshops, students were encouraged to select a chart type suitable for their dataset from recommended reading materials [28] for W7, or choose from a list of chart types covered in the course for W8. Additionally, we removed the cheat sheets from the comic construction kit. The introduction of how to use the kit remained unchanged and the workshop facilitator was available to answer students’ questions about their chart types. However, after the creation phase, instead of a Show & Tell session, the groups exchanged their comics, which allowed them to gain insights into various visualization types.

3.2.2 Participants

W7 was conducted with master’s students (13 female, 4 male, mean age: 24.6, SD: 2.98) from a communication and media study program. On the same Likert scale as used in W6, they reported limited experience with comics (1 5, Median: 2). **W8** involved 12 bachelor students (all 12 male, mean age: 22.6, SD: 3.06) from a software engineering study program, who also rated their experience with comics as low (1 5, Median: 1).

3.3 Resulting Comics

Across the eight workshops, a total of 40 comics were produced. Two excerpts are featured in Figure 1. The comics showed a range of creative approaches, with participants exploring diverse panel structures and layouts, some following our guide grid and some devising their own. In a few comics, we found issues in the sequence of speech bubbles (e.g., when the text in the right speech bubble continues in the left). Content-wise, the comics varied significantly, with some emphasizing chart reading, others construction, some focusing on the data shown in the chart, and some reporting participants’ own learning journeys, detailing pitfalls to avoid. For example, the left comic in Figure 1 explains the anatomy of an area chart, while the one on the right shows how to construct a line chart. Some participants also creatively interpreted example graphs, annotating peaks and valleys with related illustrations, or used pointing characters to highlight areas of interest. People also creatively personalized the stickers to fit their comics.

4 Participant Feedback

We progressively refined the workshops based on feedback and observations from earlier sessions. Notable enhancements occurred between W4 and W5 when we realized that younger students required additional guidance to understand the chart types presented at the beginning of the workshop. Consequently, we allocated more time to the introduction, incorporated more concrete examples, and enhanced the details in the cheatsheets. Initially, feedback collected for the first workshops (type A) was primarily qualitative and collected through a group discussion after the workshop, while in later sessions (type B), we shifted to a quantitative focus, gathering feedback through Microsoft Forms.

4.1 Qualitative Feedback

Throughout all workshops, participants uniformly expressed their enjoyment of the activity, noting the **convenience of the materials** and that they found the **creativity and interactivity** engaging, which made the task immersive and time seemed to pass quickly.

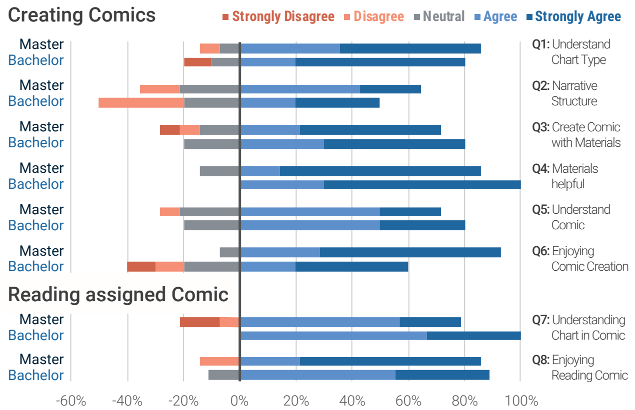

Figure 3: A visualization of participants' responses to our feedback forms in W7 and W8, regarding both the creation of the comics and the subsequent exchange and reading other groups' comics.

The use of **stickers** was well-received, with participants praising their role in facilitating creativity in all eight workshops. Especially participants from W1-W3 and W8 noted how the stickers aided those with limited drawing skills and sparked creative story ideas. The simple sticker designs easily allowed e.g., transforming a standing character into a sleeping one by rotating it. However, feedback from one lecturer, one teacher, and one student group (W1, W2, and W6) mentioned that the sticker designs and sizes could be restrictive when envisioning specific panel compositions.

School teachers from W2 and W3 pointed out the potential for employing such workshops in non-data-related subjects like Psychology or Languages and suggested that it could **engage students with traditionally dry topics**. This sentiment was shared by a student in W7, who described the workshop as a "refreshing activity" that provided a creative break between more theoretical sessions.

Managing the workshop time proved to be a challenge. Participants often came up with elaborate stories that were difficult to complete in 60 minutes. A teacher from W2 admitted to becoming so engrossed in the activity that he **lost track of time** and suspected that younger students might require more structured guidance to complete their projects within the timeframe. This issue was also reflected in our observations in W4 and the experience of a student from W7, who mentioned initial difficulties in thinking of a story.

4.2 Quantitative Feedback

In workshops W7 and W8, we aimed to gather student feedback during specialized visualization lectures which covered various chart types beyond Line-, Area-, and Stream Graphs. The feedback form focused on two areas: personal comic creation (Q1-Q6) and interpretation of comics by other groups (Q7-Q8). A total of 14/17 master students (W7) and 10/12 bachelor students completed the questionnaire. Figure 3 displays the results. Participants used a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree", to respond to the following questions:
Q1: *I quickly understood my chart type before creating the comic.*
Q2: *I could quickly conceive a narrative structure for my comic.*
Q3: *It was easy to create the comic using the provided materials.*
Q4: *The stickers and materials were helpful for creating the comic.*
Q5: *Others could understand my visualization through my comic.*
Q6: *I enjoyed creating my comic.* ***Q7:*** *I understand the visualization from the other comic.* ***Q8:*** *I enjoyed my colleagues' comic.*

Most students understood their chart types from the reading material, which was important for the basis of the comics **Q1**. There were some misunderstandings with Parallel Sets, Radar Charts, and Histograms, which were cleared up by the instructor.

The greatest challenge was crafting a narrative for the comic (**Q2**); two master and three bachelor students reported having had difficulties, rating it "2-Disagree". However, assistance from the instructor and group discussions helped overcome the challenge.

Most students found the comic creation with the materials easy, although two master students gave negative feedback (**Q3**). All students found the stickers useful (**Q4**) and were confident their comics were understandable (**Q5**), except one master student. **Q6** revealed differences: Master students responded very positively, while two bachelor students did not enjoy the activity.

All students understood the chart types in other groups' comics (**Q7**). However, one comic about the Radar Chart posed comprehension challenges for the master students, with one indicating "2-Disagree" and two "1-Strongly Disagree". This was echoed in **Q8**, where most enjoyed the comics, except for two who struggled with the Radar Chart comic and rated their enjoyment "2-Disagree".

5 Discussion and Lessons Learned

After conducting eight iterations of our workshop with diverse age groups and varying levels of expertise (see Table 1), we report on our lessons learned and recommendations for leading similar sessions. In our supplementary material, we also provide an **activity sheet** with a checklist detailing how to facilitate the workshop.

The fun factor is well received: Qualitative feedback from each session of our workshop highlighted participants' enjoyment across all age groups. The hands-on nature of the activity proved to be highly engaging (cf. Discovery-based learning by Papert [12]), and the use of the stickers was received especially well.

Finding a story takes time: While it is feasible to create explanatory comics using our kit within 60 minutes (+ time for pre- and post-tasks), feedback from participants suggests that allocating more time to developing narratives and discussing explanation strategies could improve the quality of the comics.

The process highlights knowledge gaps: The workshops also allowed us, as course instructors, to identify areas where students had gaps in their understanding by observing their process of creating comics and the strategies they chose for explaining their topics. For instance, in W5 and W6, when students used temperature data to illustrate an area chart, our intervention helped them realize the data did not suit the chart type. They then changed their story and highlighted this personal "lightbulb moment" in their comic.

Integration into a longer course is crucial: A limitation of the workshops was the absence of a feedback loop, leading to varied comic quality. Student groups receiving less developed comics benefit less than those with polished ones. Facilitators providing guidance on which aspects to structure the story around, like chart anatomy, usage, or pitfalls, could enhance the experience and fit well into a longer course. Adding a post-workshop step for students to refine and give feedback on others' comics would be beneficial. The collection of final comics could become a **collaborative learning resource**, similar to a class wiki, serving as both personal achievements and valuable references throughout the course.

6 Conclusion

We introduced a new hands-on, engaging activity using comics in the process of learning new chart types, with all necessary materials provided in the supplementary material. It was refined through eight iterations with diverse audiences, and we report our insights to support other facilitators. Future work includes a quantitative evaluation of learning effectiveness and comprehension to support our qualitative results. Additionally, we aim to systematically analyze the comics to identify explanation strategies and narrative patterns to inform the design of curated educational materials. Our presented workshop contributes to the growing body of methods and concepts for visualization education.

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