"I happen to be one of 47.8%": Social-Emotional and Data Reasoning in Middle School Students' Comics about Friendship

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ABSTRACT

Effective data literacy instruction requires that learners move beyond understanding statistics to being able to humanize data through a contextual understanding of argumentation and reasoning in the real-world. In this paper, we explore the implementation of a co-designed data comic unit about adolescent friendships. The 7th grade unit involved students analyzing data graphs about adolescent friendships and crafting comic narratives to convey perspectives on that data. Findings from our analysis of 33 student comics, and interviews with two teachers and four students, show that students engaged in various forms of data reasoning and social-emotional reasoning. These findings contribute an understanding of how students make sense of data about personal, everyday experiences; and how an arts-integrated curriculum can be designed to support their mutual engagement in both data and social-emotional reasoning.

CCS CONCEPTS

• **Human-centered computing** → *Visualization*; • **Applied computing** → **Computer-assisted instruction**; *Media arts.*

KEYWORDS

data literacy, social-emotional learning, data comics, math education, arts education, data reasoning

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1 INTRODUCTION

Data literacy can be understood as, "the ability to read, work with, analyse and argue with data as part of a larger inquiry process" [17]. For an individual to be data literate, they must be equipped to read, interpret, and make decisions around data based on its occurrence in news, politics, healthcare, finance, advertisement, and media [17, 70]. To meet these requirements, data literacy education must expand beyond the mathematical and statistical understanding of data to include a broader set of competencies such as reasoning around real-world contexts, communicating stories from data, and engaging in the critical aspects of recognizing and understanding the ethical implications of data and data practices [70].

In contrast to framing data as objective and factual, a humanistic lens on data literacy emphasizes the contextual and interpretive nature of data [45, 46]. By bringing context to the center of conversation with data, educators can integrate relevance and avoid *automistic* problem-solving and *inert knowledge* [6, 46]. In particular, the focus on context has opened up opportunities to leverage various art forms such as narrative development in *data stories* [52] as well as visual forms like murals [10] for developing data literacy skills. In these types of experiences, learners can work with data in new ways while still engaging in argumentation and reasoning. One subset of this work examines the construction and use of data comics, in which narratives are composed of visual and textual elements to convey stories about data [3]. Given their potential relevance to youth's interests and their promise for making information more accessible (ex.[67], data comics offer an under explored opportunity for students to engage in reasoning about data and social-emotional issues. In this work, the researchers examine

the opportunities to expand the humanistic approaches to data through co-designing a comic unit for 7th grade students focused on data about their friendships. We examine how students' process of constructing comics can support their data and social-emotional reasoning.

This study is part of a larger project called Data Literacy Through Art (DLTA), which brings together university researchers and cross-subject middle school teachers to co-design curriculum and resources around art and data literacy. We worked with a 7th grade art and math teacher at the same school, to co-create a data comic unit with the intention of providing students with a personally relevant context in which to develop perspectives and skills with lifelong implications. The researchers and teachers decided on friendship as a topic and on comic-making as the medium. In this paper, we present findings from the implementation of the data comic unit with 33 seventh graders, who examined data about themselves and their friendships. They practiced data analysis skills, like graph reading and statistical reasoning, while creating digital comics to communicate stories about and with the data. Specifically, we examined two research questions:

- **RQ1.** In what kinds of data reasoning do students engage through their creation of data comics? and
- **RQ2.** In what kinds of social-emotional reasoning do students engage through their creation of data comics?

Through an analysis of 33 data comic artifacts, interviews with two middle school teachers, and interviews with four student participants, we present key findings. First, through the process of constructing narratives, students engaged in complex forms of data reasoning wherein they used data and the context of their stories to determine narrative implications. These acts of comic making led to instances of informal inferential reasoning [45, 46]. Second, by centering the data on teen friendships, learners not only engaged in data reasoning but also forms of social-emotional reasoning. We demonstrate how these two competencies supported one another within their comic narratives.

The paper contributes to the literature by providing a set of illustrative examples that demonstrate the potential for data comics to broaden the ways learners can engage in data reasoning through narratives that force them to represent and construct social-emotional context around the data. We argue that comic authoring tools that focus on narrative construction, character development, and scene composition, can expand the potential for data comics by providing greater opportunities to move towards a more humanistic and interdisciplinary view of data literacy.

2 BACKGROUND LITERATURE

2.1 Data Literacy

The processes, competencies, and dispositions that are important for negotiating and working with data are everyday life skills [70]. Data literacy intersects and draws on multiple other literacies, including statistical literacy, scientific literacy, computational literacy, media literacy, and critical literacy [9, 70]. Key priorities for data literacy education in K-12 include supporting social engagement with data, participation in a process of inquiry, and development of critical consciousness [9, 62, 70]. These critical data literacy perspectives view data as situated in a social context and explicitly challenge the perception of data as neutral or objective [9, 11, 18, 53, 62, 69]. As Kitchin [39] explains, "no data are pre-analytic, or objective and independent" [39]. In this study, we adopted an inquiry-focused definition of data literacy [16, 64, 70]. Data literacy is "the ability to ask and answer real-world questions from large and small data sets through an inquiry process, with consideration of ethical use of data" [70]. The inquiry process includes asking questions, developing a hypothesis, collecting data, analyzing data, and evaluating data [70]. Traditional definitions of data literacy have emphasized a narrow set of mathematical competencies. By situating data analysis within this larger process of context-bound inquiry, we aimed to engage students in making informal inferences about data and in challenging neutral, objective representations of data.

Within K-12 math, there has been a shift toward teaching statistics as a way to reason about the world rather than as a set of procedures and calculations [8]. The goal is to broaden students' participation with data and prepare them for more advanced work, such as inferential statistics. Formal inferential reasoning requires an understanding of complex statistical techniques that are not accessible to middle school students. But students can still engage informally in this process. Makar and Rubin [45] developed a three-part framework defining *informal inference-making*. Students need to (1) explicitly identify evidence, (2) make a claim about the aggregate that goes beyond the data, and (3) articulate the uncertainty embedded in an inference. These objectives address persistent challenges that students have in working with data. For example, determining what counts as appropriate and sufficient evidence is challenging for students. They may rely on personal beliefs or fail to align data with their claims [32]. In data analysis, students often rely on case value comparisons, which limits their ability to make claims that go beyond the data [35, 40, 55]. In contrast, approaching data as an aggregate reinforces the value of calculating statistics [7, 40]. Finally, recognizing and communicating uncertainty within statistical claims engages students with tough topics such as the variability of data and challenges misconceptions that data are neutral and objective. To demonstrate informal inference-making, students might generate hypotheses, evaluate claims, or make predictions based on statistics [45].

Recent research in data literacy has highlighted the promise of arts-based techniques, such as storytelling, to engage students in constructing explanations, arguments, and inferences grounded in real world contexts [9]. Researchers also note the potential of storytelling to support data inclusion by connecting local, experiential ways of knowing to data [9, 18]. For example, students may construct stories from personal experience to reason about mathematical concepts, such as center and spread [42]. They may co-construct evidence-based claims by challenging each other to support personal stories with data [60]. Students may also broaden their understanding of what counts as data and how it can be used for personally relevant purposes [10, 59]. Telling stories with personal data can help students understand themselves in new ways, but it can also overshadow other goals such as connecting personal data to culturally or socially-relevant issues [59]. In this study, we investigate the potential of narrative-based arts, such as comics, to help students situate their personal stories in a broader social context through data and engage students in informal inference

making. We identify how their artifacts were indicative of their engagement in social-emotional learning.

2.2 Social-Emotional Learning

Social-emotional learning (SEL) has been defined as the process by which we develop our competencies to recognize and manage emotions, empathize and care about others, make ethical and responsible decisions, and develop constructive relationships [21, 71]. The importance of cultivating such social-emotional competencies is particularly important in early adolescence since internalizing difficulties becomes more prevalent, alongside increases in mood variability and intensity in negative emotional experiences [5]. In addition, adolescence is largely understood as a period in which many emotion-related words are fully comprehended, but the underlying concepts have not yet reached mature levels of abstraction [50, 51]. As crises such as the COVID-19 pandemic emerge, cultivating social-emotional competencies in adolescent education spaces has only grown in both importance and interest.

A variety of frameworks have emerged to operationalize social-emotional learning. Lipton and Nowicki [43] developed the *Social Emotional Learning Framework (SELF)* to identify the skills necessary for people to personally relate to one another. They break up the SELF into three components: (1) *awareness* – the ability to be aware of and recognize emotions in others, (2) *meaning* – the ability to understand the perspectives of others through linking social-emotional cues to the context in which they are situated, and (3) *reasoning* – the ability to use social-emotional information to construct one's social behavior and problem-solve [43]. The competencies involve both verbal and non-verbal skills as people learn to pick up on, understand, and respond to the variety of emotional signals that humans enact [43]. While verbal signals include cues that are expressed aloud, non-verbal signals include things such as *facial expressions, postures, gestures, tones of voice, distance in personal space, rhythm of interaction, apparel,* and *touch* [43]. Working within comics, provides a unique medium for us to examine how learners were able engage with verbal and non-verbal social-emotional reasoning within their narrative artifacts.

The Collaborative for Academic, Social, and Emotional Learning (CASEL) organization, which aims to make evidence-based SEL an integral part of U.S. education, posits a framework with five key SEL competencies for children and adolescents: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making [24]. This framework emerged from earlier work [29, 47] with studies supporting that children and adolescents who have acquired these competencies typically exhibit fewer mental, emotional, and behavioral problems later in life [28, 68]. CASEL's five competency outcomes framework merge and balance the cognitive, emotional, and social skills and is evidence-based [20]. Self-awareness is the ability to accurately recognize one's own emotions, thoughts, and values and how they influence behavior. Social awareness is the ability to take the perspective of and empathize with others, including those from diverse backgrounds and cultures. Self-management is the ability to successfully regulate one's emotions, thoughts, and behaviors in different situations. Relationship skills allow students to establish and maintain healthy and rewarding relationships with diverse individuals and groups. Responsible decision-making refers to the ability to make constructive choices about personal behavior and social interactions based on ethical standards, safety concerns, and social norms. SEL implementation varies widely from school-wide holistic approaches, to competency-focused approaches that may tie into curriculum [24].

One challenge in implementing SEL, is aligning the core competencies with other disciplinary content in order to integrate SEL across the curriculum [71]. Prior work has explored the use of narratives in English Language Arts and Social Studies to have students reflect on characters' decisions and problem-solving behavior. This enables students to build their emotional vocabularies as they analyze the emotions and feelings of the characters, action sequences, results of the characters, and alternative paths that the characters could have taken [21]. In this work, we explore how narratives, such as comics, can be used within math and art curricula to deepen learners' data reasoning. We demonstrate how the use of comics presented unique opportunities for social-emotional reasoning as students crafted both visual and textual artifacts as part of their work.

2.3 Using Comics to Expand Data Reasoning

Comics are a form of sequential art that communicate narratives through the interplay of text and images, often with a mix of both realistic and abstract symbols, to convey ideas and emotion [19, 48, 54]. The combination of pictures and text in comics, "offers ***range*** and ***versatility*** with all the potential imagery of ***film*** and ***painting*** plus the ***intimacy*** of the ***written word***" [48] (emphasis retained from original citation). The comic art is additive in that it can use written and drawn features to aim attention to certain details or ideas that would not be possible in a realistic drawing. For example, emanata are stylized lines that can be used to communicate speed of a moving object or stench of a garbage can. Yet, it is also subtractive, in that the cartooning of comics often removes details that would make them look more realistic. This leaves space to draw attention to what is left and allows for the readers' imagination to fill in the details [48]. Whether creating features within characters or connecting the comic panels through time and space, the reader is actively engaged with what is not there. The reader creates *closure*, building up the whole of the story from the parts, based on what is on the page and what is not [27, 48, 49]. One of the defining features of the comic art form is that the author can manipulate the panels and the gaps between panels to guide the spatial and temporal aspects of the narratives in ways that are only possible through comics [48].

The unique features of comics have led researchers to examine the ways they can be connected to data reasoning and *data-driven storytelling* through capitalizing on the spatial layout and linear narrative to present information, charts, and data, that the reader can traverse through the comic panels [4]. Bach et al. [3] highlight four main components of data comics: the *visualization* of the data ranging from the realistic to abstract, the *flow* of the comic ranging from an explicitly directed to an open format, the *narration* of the comic ranging from factual statements to a story-based format, and the *words and pictures* break down of how verbal and pictorial components are combined. Research has identified the potential for data comics to improve understanding and engagement with

data over other visual presentations such as infographics [67] while providing access to complex information such as explaining how quantified-self apps handle data [57], or explaining results from HCI research studies [66]. Creating data comics can be difficult since the medium traverses artistic and mathematical domains. Bach et al. [4] examined the design space for data comics in order to provide design patterns that could help guide their construction. Others have convened comic artists and data scientists in workshops to integrate their expertise in the data comic construction process [65]. Technologies have also been developed to scaffold the authoring of data comics. Some of the tools are datacentric such as DataToon [38] and ToonNote [37], which are focused on how learners can create new visualizations through complimenting data representations with textual information to communicate narratives about the data. However, these are limited in that they forefront issues of data visualization, and fail to take advantage of the complementary opportunities in comic design, such as in the creation of characters and settings. Although not typically focused on in data comics, there are a variety of comic and digital storytelling tools that are intended to support users of all abilities. These include BitStrips (which was morphed into Bitmoji), Comic Life, MakeBeliefComix, and Pixton (*review in* [2]).

In our work, we explore Pixton, a tool designed around users' ability to tell stories rather than represent data. Pixton has been previously used in educational research contexts. For instance, the tool has shown to motivate and engage students while sustaining gains in learning in English as a Foreign Language (EFL) classes in Ecuador [12]. Furthermore, in their study, Smith et al. [58] demonstrate how Pixton can be woven into a multimodal experience, where learners create science fiction narratives to explore a variety of scientific concepts. Compared to other digital storytelling tools such as Bitstrips, Comic Life, MakeBeliefComix and Cambridge University's Comic Builder, Pixton earned the highest scores across 12 dimensions of storytelling, with its highest ratings in *Cognitive Effort*—"the required user understanding to create stories", *Control*—"how much control is given to users in narrative evolution" *Immersion*—"how much a user is drawn into the narrative" [2]. With respect to *Control*, Pixton offers users with flexibility in setting scenes in their comic panels as they are able to choose from a variety of backgrounds and perspectives (zooming in and out) as needed.

The exploration of digital comic tools that focus on the character and setting development is important for data comics to be centered within the larger movement to *"feel"* [44] and experience data in ways that can contextualize and humanize the data and data processes [1]. The narrative form of comics can provide characters and settings that can be leveraged for a humanistic understanding of the data. Toh et al. [61], for example, demonstrates how the comics opened up opportunities in the math classroom to stimulate discussions about privacy and confidentiality within data practices. Learners were able to engage in perspective taking of the comic characters as they discussed the ethics behind the characters' decisions [61]. Our work taps into these opportunities within data comics to connect them to the needed contextualization for learners to engage in inferential reasoning. We demonstrate how the digital comics and technology supported learners in focusing on the human side of the data that supported them in reasoning around their data as they explored the social-emotional dimensions within their narratives.

3 METHODS

3.1 Context and Participants

Participants included 33 7th grade students who were in both math and art classes from a public school in an large urban city in the Eastern United States. The school serves a diverse student population: 33% White, 32% Black, 16% Hispanic, and 16% Asian. 46% of the student population qualifies for free or reduced lunch, 18% of students have disabilities, and 4% are English Language Learners. While there were more students that participated in the unit, not all of the students in the art class were in the math class, and vice-versa. Furthermore, shifts in scheduling due to COVID restrictions further complicated the possibility of students attending all of the sessions with both teachers, so some participants that initially were in both classes were switched out. Consequently, two entire classes (about 42 students) were dropped from the study. However, the use of the comic artifacts in our analysis still enabled us to understand how learners were engaging and reasoning around data and the social-emotional contexts developed throughout their narratives.

3.2 Unit Description

One math and one art teacher in the same school taught the data comic unit during the Spring 2021 semester. In the art classroom, students convened once a week over a six-week period, which amounted to about one-third of their semester's art classes. The math portion of the unit ran three times a week for two weeks and was integrated within a larger unit on statistical reasoning. The art class started prior to the math unit.

Researchers co-designed the unit with the teachers starting in the prior semester. Researchers met biweekly with teachers either together or separately to coordinate across and within both domains of art and math. During the planning phase, the teachers chose the topic of friendship as the focal point of the unit, because they were interested in helping students foster *life skills*. The art teacher wanted to build on a comics unit that she had previously implemented in her class. The teachers and researchers chose this medium because of the narrative quality of comics, the closeness of comics to youth's existing interests, and the available tools for comic-making to offer an accessible medium for telling stories about friendship. Teachers also felt strongly that students should analyze their personal data.

To provide students with a set of personally-relevant data about friendships in which to ground their inquiry, the research team developed a 17-item survey, using Google Forms, on friendship based on similar questions asked on a PEW survey on teens and technology use [13]. While the PEW survey focused broadly on teens and technology, the 17-item survey focused primarily on beliefs about friendships, their describing their own friendships, and certain friendship experiences (e.g., bullying experiences). As described in Table 1, these items aligned to four categories.

The teachers provided this survey to all four 7th grade classes in the school (N=92) during their math class. Researchers cleaned and analyzed the survey data. Because the math teacher wanted students to focus on graph reading and inference making in this

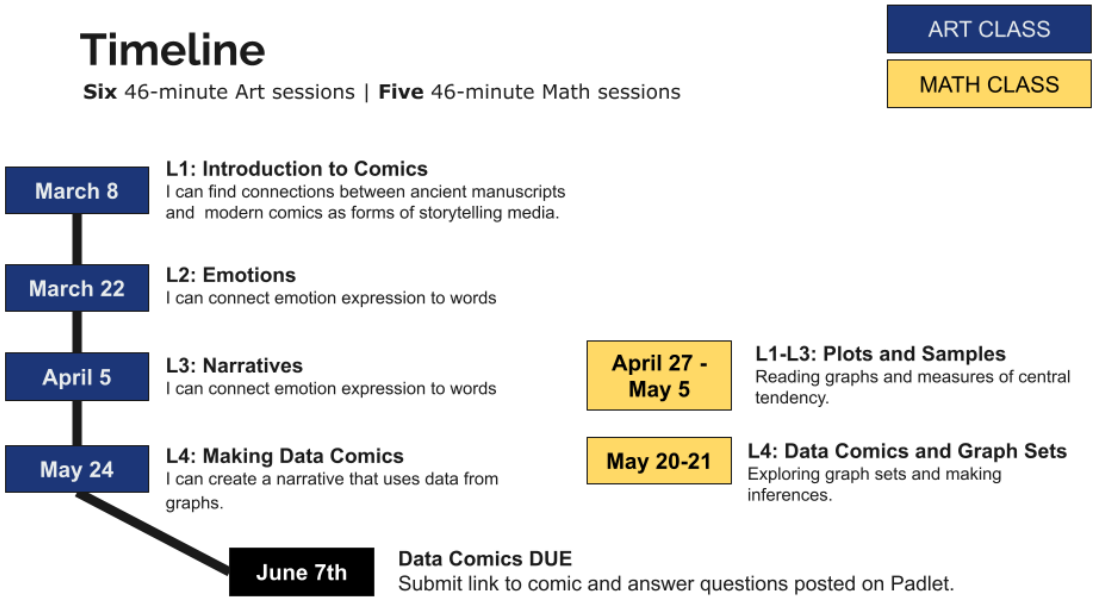

Figure 1: A timeline of the unit implementation

Table 1: Sample Survey Questions

Category	Example Question	# of items
Beliefs about Friendship	How much do you agree/disagree with the following statements? [It's okay to walk away or take a break from relationships that aren't supportive.]	3
My Friendships	How many of your CLOSE FRIENDS are... [In this school, online, female, non-binary, male]	3
Friendship Experiences	Which of the following describes you and your friends? I can count on my friends when things go wrong	7
Demographics	Which gender do you identify with?; How often are you lonely?	4

unit, the researchers created graphs including boxplots, dot plots and bar graphs based on the survey data. Students based their data comics on their interpretations of these graphs.

In the art sessions, students began in the first lesson (A1) by exploring comics as a storytelling approach. Building off of prior lessons around ancient manuscripts, students explored comic vocabulary and elements such as panels, bubbles, transitions, captions, by viewing and discussing comic examples. In the second lesson (A2), students started using Pixton to create single-panel comics focused on expressing emotions using facial expression, body positions, colors, zooming, and environmental backgrounds. In the third lesson (A3), students explored narrative arcs using a three-act story structure. Using Pixton, students created multiple-panel comics that provided a context, conflict, and resolution. In the fourth lesson (L4), students focused on building narratives from graphs analyzed in math class.

The week when students began their third lesson (A3) in art class, they also began their initial math lessons, focusing on reading graphs generated by the research team using the student survey data. In the first math lesson (M1), the students focused on making claims using dot plots and bar graphs, while the second lesson (M2) focused on box plots. In this third lesson (M3), the focus shifted to samples contrasting the 7th grade survey questions against the national sample from a Pew research dataset of teenagers' attitudes about social media and friendship. In the final lesson (M4), students created their data comics in both their math and art class. In math class, students selected one of the graphs to explore through their data comic, followed prompts that asked them to make claims from the graphs they selected, identified an argument about friendship that they felt was important to share, and finally, used a comic to communicate this claim. In addition to creating their data comic, students generated artist statements to reflect on their message and data. Students were made aware the unit was part of a research study on connecting comic-creation with data literacy, and a rubric was co-designed by the math and art teacher to provide feedback on the data comics (see Table 2).

Table 2: Data Comic Rubric

Level of Performance	Excellent Understanding Demonstrated	Strong Understanding Demonstrated	Unclear Understanding Demonstrated	Little to No Understanding Demonstrated
My Claim	I made a clear and accurate inference about the data.	I made an accurate inference but it is somewhat unclear.	I made an inference but there are some errors or I made an inference that is somewhat supported by the data	I did not make an inference or I made an inference that is unsupported by the data.
My Evidence	I correctly used at least two statistical measures to support my inference or I compared two or more measures from two or more groups	I correctly used one one statistical measure to support my inference	I used one statistical measure but it does not support my inference	I did not use any evidence to support my inference
My Artist Statement	I can describe why I selected the visuals I used and how they relate to my claim, my evidence, and my argument.	I can partially describe why I selected the visuals I used and how they relate to my claim, my evidence, and my argument.	I can describe why I selected the visuals I used but I did not describe how they relate to my claim, evidence, and/or argument.	I cannot describe why I selected the visuals I used nor did I explain how they relate to my claim, evidence, and argument.
My Message about Friendship	I constructed a clear message that helps my peers reflect on friendship.	I constructed a message about friendship but it is not entirely clear what my message is.	I constructed a message that is clear but not related to friendship.	I did not construct a clear message.

Because of the pandemic, teachers co-designed and implemented the data comic unit remotely, mostly coordinated through the suite of Google Apps for Education. Although this format was familiar to students, and facilitated researchers' and teachers' real-time collaboration over the instructional materials we were co-designing, it also presented various logistical and pedagogical constraints. For example, the art teacher expressed concern about the students' abilities to create comics without their having access to the drawing materials that they would have in their classroom. The art teacher was initially hesitant to adopt a new digital tool. However, after reviewing it, she became excited about the potential for the tool to support students in quickly creating comics while also covering important topics about the art form, such as scene composition, character creation, narrative development, and communication through text and visuals. The key to the success of the tool was that students would not require significant support from her to begin using it.

3.3 Pixton Comic & Storyboard Builder

Pixton is a tool for digital storytelling through comics developed by Clive and Diana Goodinson in 2008 [31]. Pixton provides users with the ability to rapidly construct comics using a library of predefined content that the user can manipulate to build visual and textual narratives. We chose the tool in collaboration with the teachers who needed something that could work in a remote context, enabled students to create artistic artifacts without additional tools or materials (outside of the computing devices they were already using to connect to class), and supported a range of expertise. Within the tool, users create comics by adding and designing each panel–situating characters, objects, and text within settings. As illustrated in Figure 2, the panels have three main components that can be manipulated: the background and setting elements, the characters including their outfits, facial expressions, and body movements, as well as the textual components.

3.3.1 Background and Setting. The tool provides hundreds of backgrounds that can be searched for by the user. This includes a diverse set of indoor and outdoor scenes that represent real and fictional settings across cultures and contexts, from various house interiors, to graveyards and concerts, to underwater ruins and planetary landscapes. The content also includes options that are artistic in nature, such as a spiral or a frame full of colorful question marks, that can be used to convey a certain aesthetic. The user can then choose the focus of the scene which allows them to choose from preset zooms within the chosen background. The user can tint the scene to make it appear to be different times of the day, and can choose to draw attention to a particular panel by integrating a monochromatic tinting across the characters and background (such as turning the characters all a shade of red and the background elements all a shade of blue). Additionally, the user can add overlays of weather (various types of wind, rain, and snow), symbols (such as arrows and explosions), and predefined text art such as the iconic comic *POW!* in bubble letters with an explosion behind it. Lastly, there is a feature to upload an image for your background; however, it had several limitations and thus we were not able to use it.

3.3.2 Character Controls. The tool provides a selection of over a thousand characters that users can choose to start from. Users can customize the clothing, skin color, hair color and style, facial expression, eye gaze, body position, and location of the character in the frame. They can also choose from hundreds of clothing options

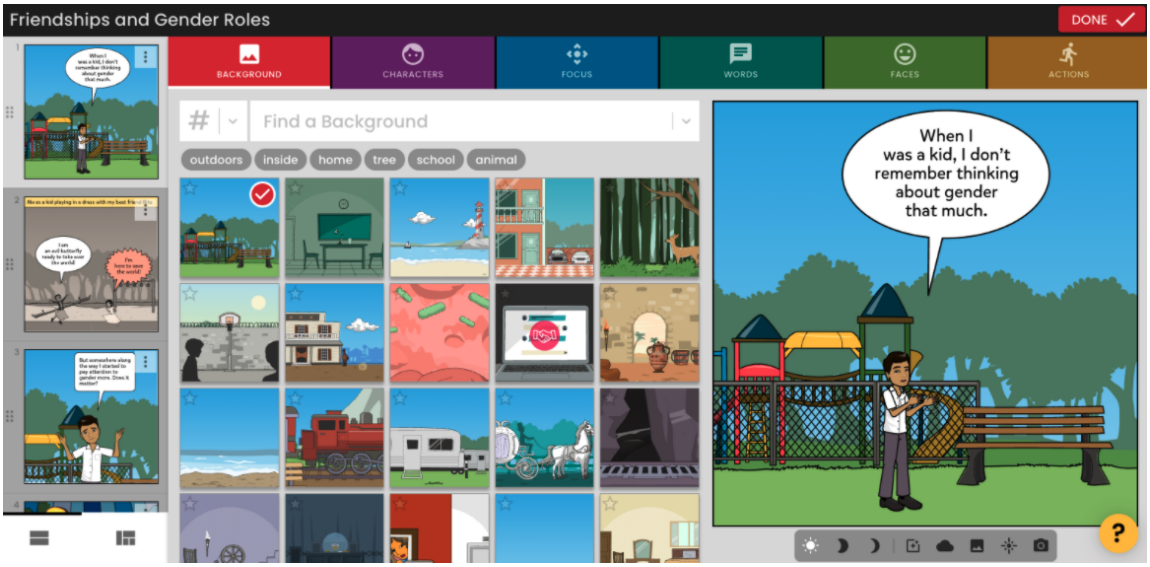

Figure 2: Screenshot of the Pixton tool

that represent a diverse set of contexts and cultures from space suits and animal costumes to gladiators and togas. The tool provides a subset of skin colors that are automatically linked to certain options for hair and eye color. This limits options such as being able to create a dark skinned character with blond hair. The tool does provide options for non-natural skin and hair colors like green, blue, and purple. For the hair styles, the user has a selection of just over a hundred to choose from that have a range in textures.

The user can add emotive features to their characters such as facial expressions and body positions. The facial expressions range from those that are expressed on the character's face to those that can be expressed through symbolic representations such as an explosion coming off the top of the head to indicate anger or a question mark to signal surprise. In Pixton, one can search through a list of facial expressions by using social-emotional vocabulary, selecting from predefined emotions or typing in your own. You can also link multiple emotions together within your search such as *concerned* and *hurt* which will give you a different subset of results compared to *concerned* and *angry*. Additionally, the user can manipulate the gaze of the character. The tool will automatically link the gaze to either the audience if it is the only character or another character if there is more than one. The user can change it to point to the audience, up, down, left, right, or any combination of directions (ie. left and down). Lastly, the user can manipulate the body position and location of each character in the panel. Similar to facial expressions, the user can search through a menu of body positions using predefined terms or their own. They can use actions and emotions in their search terms and choose the direction of the way the character is facing (either left, right, or head on). The user can drag characters around the frame and set them in relation to another character as well as to the background and foreground components. Depending on the selected background, the tool often limits the users placement of the characters to a particular plane (ie. only allowing characters to be moved horizontally on the ground).

3.3.3 Textual Components. The final addition to the comic panels that users can manipulate is the textual components. These come in the form of captions and four forms of text bubbles: speech, thought, shout, and whisper. The *thought* bubble makes the bubble look like a cloud, the *shout* creates jagged edges to the bubble and turns it an orange color, and the whisper makes the bubble semi-transparent and puts a dotted line around it. The bubbles move automatically with the characters position on the screen, and the user cannot change it. The captions can be placed at the top, bottom, or center of the panel. For the top and bottom choices the rest of the panel remains, but in the case of the center it takes up the whole thing removing the characters and background, allowing you to set an aesthetic background instead.

3.4 Data and Analysis

3.4.1 Data Reasoning. To answer the question, what kinds of reasoning do students engage in through their creation of data comics, we pulled from three different data sources: (1) data comic artifacts, (2) group interviews with four students, and (3) individual interviews after the implementation with each of the art and the math teacher. We also triangulated this data through cross-referencing and contextualizing with our co-design meeting notes and artifacts that we draw on.

The 33 data comics created by the students were coded (see Table 3) through a social moderation approach [25] where a team of four researchers made independent ratings then discussed their codes to come to a consensus around social-emotional and data reasoning.

Two group interviews with a total of four students were conducted remotely through Zoom. The students were selected to be interviewed based on provided assent and parental consent, and recommendations from their teacher, based on whom they felt would be good at talking about their work and reasoning. The students' comics were representative of the comics created by the class, in that the codes mirrored the most prevalent codes. In the group

interviews students were prompted to walk through their comic and then answer questions that focused on their reasoning: (i) what did you want the comic to communicate, (ii) why did you choose this statistic as a focus, (iii) how did the project impact your understanding of friendship, and (iv) what was your process for coming up with a narrative for your data comic?

In analyzing the student and teacher interviews, we looked through the interview transcripts for statements that would provide context for the data reasoning patterns found in our analysis of the comics. In this way, we sought to better triangulate the data to give access to provide a more complex and rich description of data and social-emotional reasoning, including instances that were dissonant or complimentary to coded comics [23].

3.4.2 Social-Emotional Reasoning. To answer the question, what kinds of social-emotional reasoning do students engage through their creation of data comics, we also analyzed the three data sources: (1) data comic artifacts, (2) four student interviews, and (3) two individual teacher interviews.

For coding verbal SEL components, the researchers applied a framework from the non-profit Collaborative for Academic, Social, and Emotional Learning (CASEL) [24]. Their framework identifies five components of SEL: (1) self-awareness, (2) self-management, (3) social awareness, (4) relationship skills, and (5) responsible decision making. Through the coding process, the researchers refined the definitions offered in CASEL to those found in the final codebook (see Table 4). Three researchers went through four iterations of coding verbal SEL components, starting with individually coding then shifting to collectively coding the first subset (10 comics) and eventually the full data set (33 comics) refining the definitions at each iteration ensuring that the definitions supported the ways in which they were being applied to the comics. Once a consensus was reached on how the SEL categories were applied to the comics, the researchers tagged each comic for the five categories of SEL identifying which panels they recognized in SEL reasoning. The researchers looked for consensus across the comics themselves as to what SEL competencies they integrated rather than consensus across the panels since the codes typically spanned multiple panels and depending on how one interpreted the beginning or end of the social interaction it could be different. The researchers cared most about what types of competencies were present within the comic as a whole. The teacher and student interview data were analyzed for statements that would provide context to the SEL reasoning patterns found in our analysis of the comics.

3.4.3 Non-Verbal Social-Emotional Reasoning. We analyzed the data comic artifacts using a coding scheme focused on understanding how learners leveraged Pixton's ability to manipulate the facial expressions and postures of the characters in order to communicate affective, non-verbal components of their narratives. Two researchers conducted three rounds of coding the comics for the number of: (1) facial expressions used in support of communicating emotional states of their characters, and (2) body postures used in communicating social or emotional states of their characters (excluding those only connected with actions).

4 RESULTS

4.1 Data Reasoning

Our analyses demonstrate that students were able to engage in various types of data reasoning within their comics (Figure 3). All 33 of the comics integrated some form of data reasoning. The most prevalent form of data reasoning was the descriptive integration of data, which involved integrating a statistic within the comic narrative. This was arguably reasoning that required the least amount of inference, as it required stating a relevant statistic. However, only three comics stayed at this level of data reasoning, while the rest integrated more advanced forms. The next two most common types of data reasoning tagged within the data comics were *contextualizing the data* (78.79% | 26 comics) and reflecting on an *individual experience* representative of a data point in relation to the relationship communicated in the data (72.73% | 24 comics). The final three forms were less prevalent: reflecting on the *implications of the data* (33.33% | 11 comics), articulating *inquiries about related data* (30.3% | 10 comics), and making *proportional comparisons* between two data categories (9.09% | 3 comics). Almost none of the students used probabilistic reasoning about certainty or uncertainty. On top of the data reasoning that we identified, there were also mistakes integrated into how some of the comics were referencing or reasoning about the data. Of the 33 comics, 9 (27.27%) had some form of *incorrect interpretation*. We will examine how these codes manifested within the Findings section.

4.2 Social-Emotional Reasoning

As indicated in Figure 4, almost all comics included a character in the narrative demonstrating *self-awareness* (90.91% | 30 comics). Approximately two-thirds of comics reflected *relationship skills* (69.70% | 23 comics) and *social awareness* (66.67% | 22 comics). Students were least likely illustrate behaviors within the comic narrative—i.e. *self-management* (21.21% | 7 comics) and *responsible decision-making* (12.12% | 4 comics).

An analysis was also conducted to explore what percentage of data comics coded with a certain data reasoning code, also had a co-occurring SEL code.

In addition, students leveraged the visual components of the comic media to integrate non-verbal indicators of social-emotional reasoning. This is distinctive in setting comics apart from other forms of narratives that do not have a visual component tightly integrated with the textual component. Across the 33 comics there were a total of 238 facial expressions and 155 body postures coded for supporting the social-emotional components of students narratives. The average number of facial expressions coded per comic was 7, with a minimum of 2 and a maximum of 15. For the body postures, there was an average of 5 coded per comic with a minimum of 0 and maximum of 14 used within the comics. The data indicates that students took advantage of the visual manipulations of the characters using facial expressions slightly more than body positions as they built their narratives.

5 FINDINGS

Our findings are organized based on the types of data reasoning we found within students' comics (RQ1). Through examples, we

Table 3: Data Reasoning Codebook

Code	Description
Incorrect Interpretation	Incorrect or partially incorrect interpretation of the data in support of an argument
Descriptive	Lists a data point, percentage, or descriptor of the data
Contextualizing the Data	Interpretation of the data relationships in relation to context. Generalizing to context
Individual Experience	Reflecting on an individual experience (or data point) in relation to the relationship communicated in the data
Proportional Comparisons	Uses percents to compare different categories in the data.
Implications of the Data	Reason about how data or other evidence support a hypothesis or claim
Inquiry about Related Data	Engages in inquiry or makes an assumption about a data relationship by connecting it to another variable or relationship that is not present in the data

Table 4: Social Emotional Learning Codebook Based on CASEL Framework [24]

Code	Description
Self-Awareness	Any character describes or reflects on their own emotions, thoughts and values
Self-Management	Any character engages in or reflects on behaviors to deal with their emotions over time or across contexts
Social Awareness	Any character reflects on other characters or audience members perspectives
Relationship Skills	Reflection on a specific skill that is important for establishing and maintaining relationships
Responsible Decision Making	Reflection or demonstration of characters making caring and constructive choices about personal behavior and social interactions across diverse situations

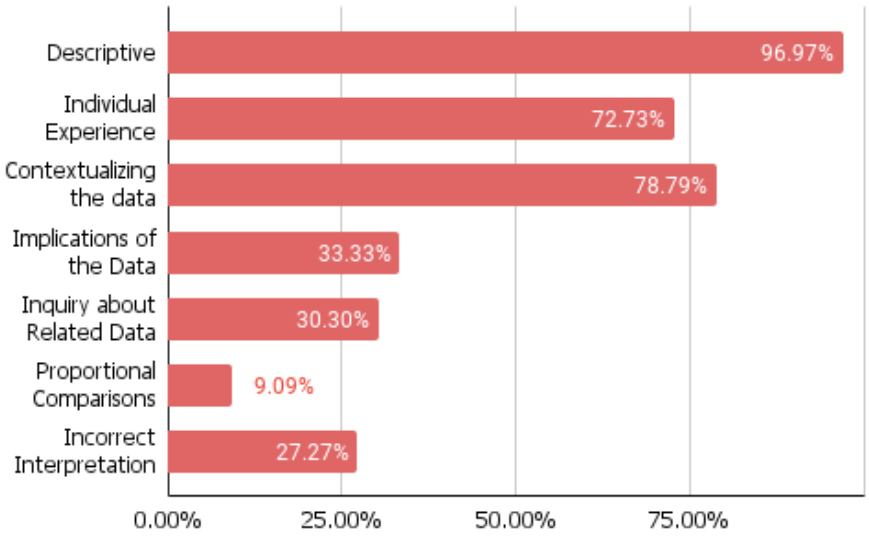

Figure 3: Graph representing the percentage of comics coded as exhibiting one or more data reasoning competencies

highlight how particular types of data reasoning and associated social-emotional reasoning were apparent within the comic narratives (RQ2).

5.1 Describing

In comics coded as "descriptive," the narratives described a data point—most often, a percentage or a few related percentages from

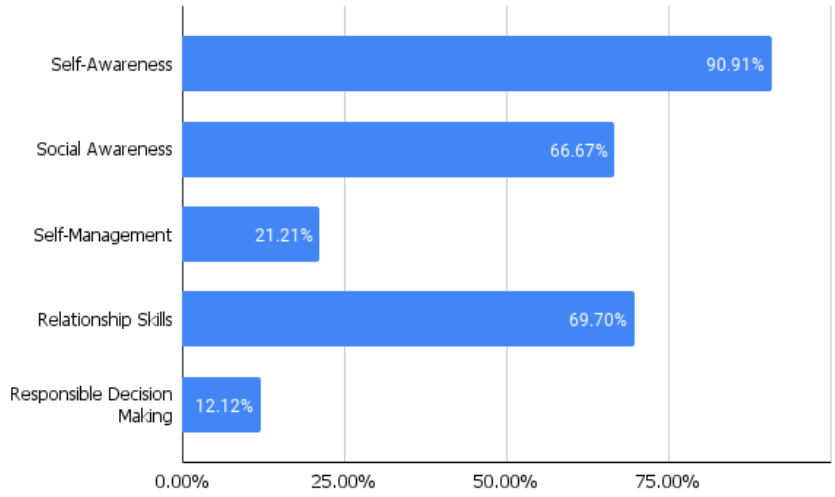

Figure 4: Graph representing the percentage of comics coded as exhibiting one or more social-emotional learning competencies

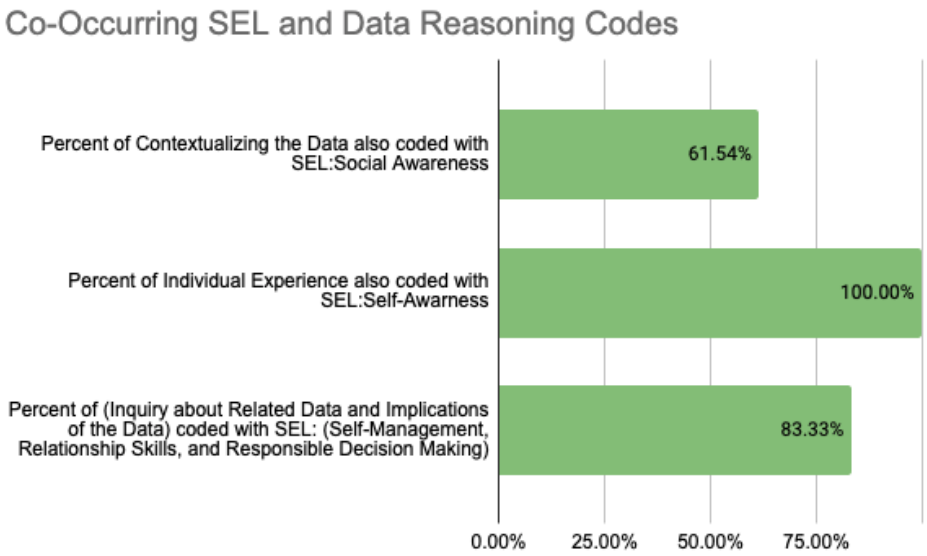

Figure 5: Graph representing the percentage of comics coded with a certain data reasoning code, that also had a co-occurring SEL code

the student or national survey data. Although most comics included descriptive reasoning about data along with other types of data literacy reasoning, three comics focused only on describing the data. The example in Figure 6 is demonstrative of this type of story in which the data is present (integrated into the speech of one of the characters in panel 2 and 3), but does not have a bearing on the narrative—i.e. they could have had data about anything and it would not have changed the story.

While the data reasoning stayed at the descriptive level in this example, this comic is indicative of how the comic construction process around the theme of friendship still presented room for social-emotional reasoning. The comic centers on a fight between two characters, which is caused by one character rattling off irrelevant data and punching the character that is annoying him. While the response seems a bit exaggerated given the context, the character that started the physical fight engages in self-management skills by apologizing for their past actions, and both characters demonstrate relationship skills through their resolution of the conflict. The author of this comic integrated 12 different facial expressions and 12 different body positions to bring the social-emotional components of their narrative to life through non-verbal cues. This example demonstrates how designing comics around friendships

Figure 6: Data comic (C14) on counting on friends when things go wrong

supports opportunities to engage in thinking about SEL. However, the lack of a meaningful attention to data seemed to lead to shallower reasoning about both SEL and data. In the remainder of the sections, we identify how the data reasoning codes connected to some of the SEL codes to demonstrate the ways in which they were mutually supportive of one another (RQ1 & R2).

5.2 Narratives to Contextualize the Data

"Contextualizing the data" emerged within the majority of the comic narratives (78.7%) and often consisted of students illustrating the kinds of friendship and interactions that the data might represent. We found that contextualization was well supported by the social-emotional reasoning code "social awareness" with 16 of the 26 "contextualizing the data" comics (61.54%) co-occurring with this code. For instance, in the comic in Figure 7, the student uses the data on student responses to the question: *"do you find it easy to make friends?"* and uses her narrative to consider reasons that influence student responses. They develop a narrative around making friends "at a young age", engaging in a broad inquiry of the importance of the variable "when and how you met your friends" as it relates to how easy or hard you find it to make friends. In an interview, the student author describes how they reasoned around related data:

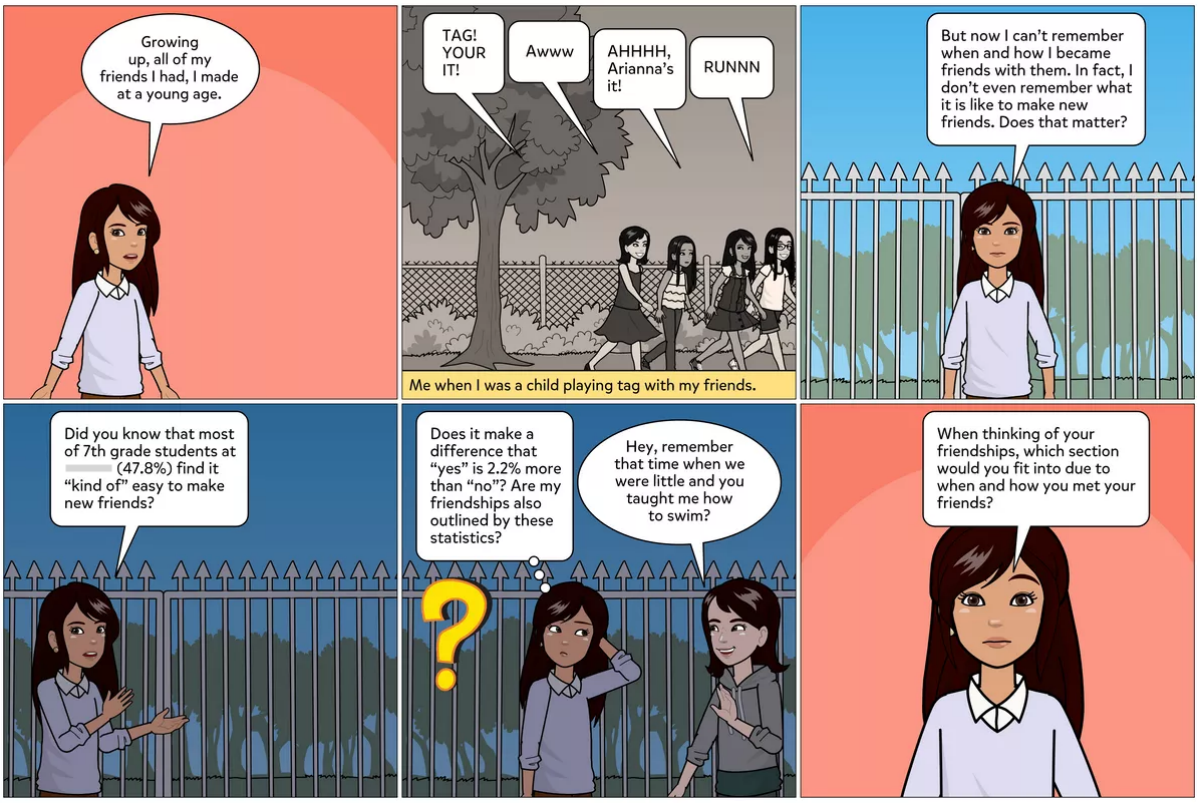

Figure 7: Data comic (C7) on making new friends and long-term friendships

> *"I kind of wasn't surprised because a lot of the kids here became friends at a young age because we were in the same classes and everything. So when I saw "kind of", I kind of thought maybe that's because certain kids, they make friends at a young age age."*

In further describing their reasoning process, the student also engages in perspective taking as they try and examine why students might reply a certain way, and what they may have felt, as it relates to the survey response,

> *"...they make friends at a young age. They don't know how it was to make the friendships. I don't know if it's hard or easy. They kind of just did it because they were young. They weren't really nervous at the time and they didn't really have to care that much."*

In the comic, in panel five, the student contrasts facial expressions, icon usage, and body positions between two of her characters to reinforce the verbal narrative as she questions the data in context, demonstrating one character's internal confused mental state and the other's social engagement. Additionally, the thought bubble demonstrates the student making sense of the data as she conveys her uncertainty of whether 2.2% is significant.

In other instances of contextualization and social awareness, students considered the role of race and other aspects of identity in their relationship to making friendships, and reasoning about the statistical interpretations within their data. When asked if there were other things that the survey on friendship was missing, one student responded:

> *"I feel like they need bullying and maybe something close to friendships with how you make the friendship in life when it works out. For example, if you're maybe a person of color it could be difficult for you to make friends, or if you have a disability or reasons why you might be excluded or reasons why you might not feel like you can make friends."*

Though these reflections, it is clear that some students leveraged the data to think about the contextual characteristics that might make it harder to make friends in certain settings.

5.3 Situating the Self In Data

The second most common type of data reasoning involved students describing an "individual experience" (data point) within the data, that is, situating a personal experience within a broader pattern shown in the data (72.73%). The 24 comics coded with this code were also coded with the SEL competency of "self-awareness", and in their narratives it became clear how these supported one another. The narratives often integrated a character that reflected on the data and where they fell within it. For instance, in the data comic in Figure 8 the character reflects on their own perspectives of the difficulties making friends because it's *scary* and *nerve wracking* which makes them part of 47.8% that finds it "kind of easy, but also

kind of hard" to make friends. The author of this comic uses a range of facial expressions and body postures to convey the hesitancy of this character (panel 1-4) that shifts into determination to change their behavior (panel 5) and finally into success at overcoming their fear and becoming friends (panel 6). The author contrasts this character with the other who demonstrates laid back and open postures with excited and happy facial expressions.

Through their comics, students demonstrated an awareness of the reasons for their characters' feelings and actions. For instance, a character describes that 49.35% of students that responded to the survey noted that shyness was the reason they felt it was hard to make friends. They go on to state, "But when I was growing up I didn't really talk to people much and I think that's why I got pretty shy talking to people, does it affect me making best friends?"

Other students used their comics to illustrate things that were surprising based on their own experiences. For example, in one comic, a character reflects on how they would always get in trouble because they never had anyone to *"back [them] up"*. They flash back to a 4 panel memory sequence of them getting suspended because another kid started a fight with them. The character ends by identifying how they were "surprised to see that according to <school>'s survey that 54.3% of students believe that they could count on their friends when things go wrong."

The interviews we conducted suggest that, for at least our four interviewees, their comics reflect students' own perspectives and emotional states. In one case, the comic helped the art teacher identify an get help for a student that was potentially struggling with depression:

> *"yeah one of the kids in her one panel came out saying like...'I don't know why I'm so sad all the time', so sad... and I was like 'oh Okay', so I reached out to her and guidance and everything so...I'm hopeful that you know, that was an outlet for her."*

The teacher further reflected on their hope that this exercise also helped students to reflect on their friendships in a positive way. Finally, although this rarely occurred, when students went beyond the individual experience to describe data in the aggregate–such as how others felt or related to others in contrasting ways–they also engaged in social awareness and perspective taking.

The utility of data on self-awareness was also reflected on by one of the students, when asked what kinds of data might be relevant in future data comics on friendship,

> *"Maybe possible data on how a person acts and stuff or how they see themselves, maybe they see themselves as more of a social person, I guess, or maybe more of a type of person that maybe gets angry that thinks a lot, and then say how many friends they have or something, or how well they have friends. And so, I feel like data like that could help me, I don't know, improving and stuff."*

5.4 Going Beyond Data

The process of creating the data comic prompted students to go beyond the data by either inquiring about the data, or to consider the implications of the data analyses. For instance in one comic, the student considers the statistics around teens with online friends and relates it to a hypothesis for the future, "So now that life is coming more technology based, even with the pandemic, I wonder if we are going to see more teens start to make online friends." They then link this to their understanding of how this changes how friendships manifest, "[online friendships] are a lot different than normal friendships, it is usually calls, and text messages, and not seeing their face."

In most instances, reasoning beyond the data led to the consideration of behavioral changes and associated social-emotional competencies such as self-management and responsible decision making. For example, comics illustrated characters shifting perspectives in things such as how they will approach new friendships and how they will change how they engage with others online. In Figure 9, the student reasons about implications of the data as a means for self-management.

In the narrative, the author creates camaraderie between three friends, two of which are empathizing (verbally and non-verbally) with one character's experience getting bullied. In panel 5-6, one of the character finds out a statistic that they use as a means helping the other character rethink their emotional reaction to bullying. They connect the high frequency of "drama" to the need to decrease their emotional reactivity to being bullied (e.g., "no big deal"). The character who was bullied ends the comic, with a changed perspective using the data to self-manage their feelings around being bullied. This connection between the use of data to reflect on how one might manage their emotions was not just enacted through comic narratives, but in the way student authors reflected on their reasoning process. For instance, one student shared:

> *"This made me see that I'm not the only one that's struggling and it's okay because there's still kids that are going to find it easy and they're going to know how to become your friend properly. It shows that basically everyone has a little bit of trouble for the most part and I'm not alone when it comes to how I view making friends."*

In addition, "going beyond the data" codes frequently co-occurred with and supported engaging in thinking about external, relationship-related skills. In the data comic in Figure 10, the student not only engages in reasoning about the implications of the data, but extends those implications to making decisions about their social media use. They first identify how 15.2% of the class does not use social media, then go on to pose a set of questions related to the effects of social media, why people might not use it, and whether there are benefits to not using it. Through the narrative the author demonstrates an evolution through time in how the main character spends their time.

6 DISCUSSION

This study explores the role that comics can play in supporting data reasoning and social-emotional learning. Our results demonstrate that students created rich narratives that reflected a broad variety of contexts, characters and emotions. Moreover, comic-making engaged students in identifying what a data point means and connect it to context through describing and illustrating the data within their narratives.

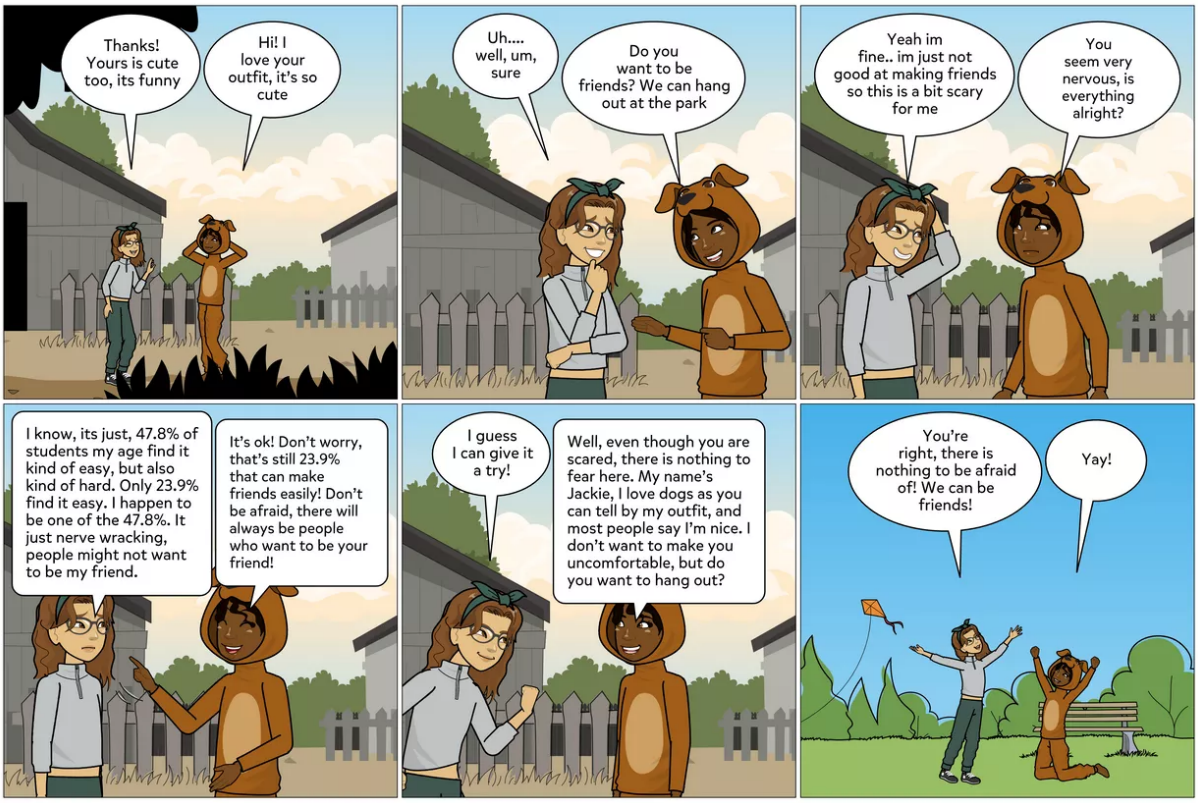

Figure 8: Data comic (C05) on counting on friends when things go wrong

6.1 Making Comics and Data Reasoning

The kinds of data reasoning students engage in through their creation of data comics, are the kinds that "humanize the personal narratives behind the numbers" [1]. Narratives that are constructed from processes such as situating oneself in the data, considering the contexts in which data lives, and reflecting on the implications that data may have. The construction of data comics enabled learners to explore their own narratives and social-emotional lives that the data represent and hypothesize about other narratives implicit in the data. The students brought context to the data and communicated about it. Using informal inference, students engaged in theorizing to explain or account for the data in relation to the context. In line with Cobb [14]'s verbal/interpretive conception of statistical reasoning, the narrative paved the way for students to engage in reasoning about other factors or measures that might explain the observed pattern.

In addition, the interviews with students and teachers indicated that many of the students reflected on their own situativity within the data. Prior work has explored the advantages of first-person "actor perspective-taking" in data reasoning such as work by Roberts and Lyons [55] where learners imagine themselves represented visuo-spatially inside datasets, and work by Kahn [35] where students situate themselves in longitudinal data about family histories. The comic medium supported the students in unpacking, where they or their characters fell within the data and what types of experiences may have led to a particular position.

Furthermore, we saw evidence of students reasoning around how the data may be implicated in the future of the characters and their behavior or actions around building and maintaining friendships. Similar to what Curcio [15] called reading beyond the data, here students made inferences from the data (e.g., pandemics might increase online friendships) by tapping their existing schema for information (e.g., online friendships are a lot different than normal friendships) that is not explicitly stated in the data.

One of the challenges for data reasoning is finding a signal from the noise and variability in the data [41]. The comic format enabled the students to incorporate more than one narrative within the data, such as that of a character that finds it easy to make friends and a character that finds it difficult. In their stories, students explored how these differences in experiences might lead to characters' different responses to their comics' narrative circumstances. Through the digital storytelling learners confronted these uncertainties as they created their characters, scenes, and short stories.

In some cases, students were able to move from reasoning about how they fit with the data to describing others' perspectives on friendship. However, these descriptions were rare, as were proportional comparisons that required identifying and then comparing groups. When students engaged in this kind of sophisticated reasoning, social awareness was also present. Furthermore, some of

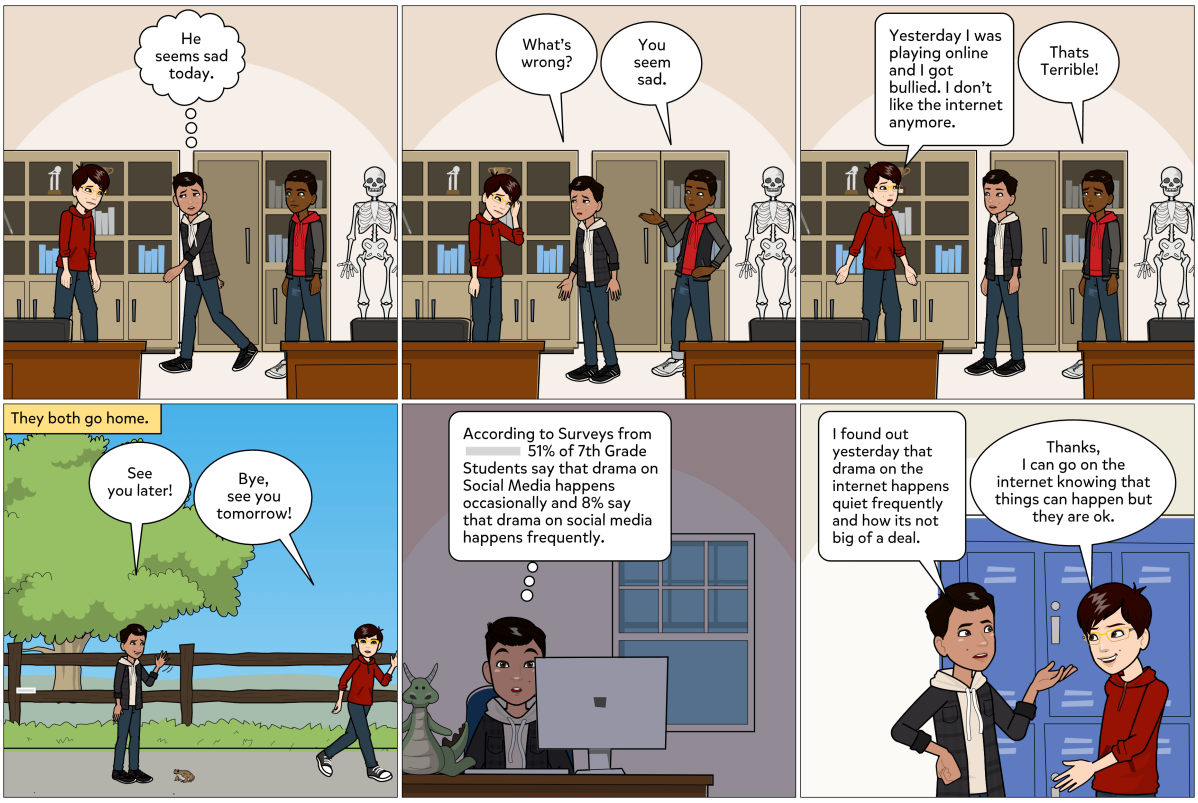

Figure 9: Data comic (C22) on online bullying and frequency of drama

the narratives integrate assumptions and biases about the data and data points that are not supported, and in a few cases, students made errors in their interpretations. The comic form provides the opportunity to elaborate on what is not there. However, we see this as a potential jumping off point to use the comic artifacts as not the final conclusions drawn from the data, but as a tool within the sense-making process. In line with research by Hancock et al. [30], there are a variety of challenges in connecting students' statistical questions to the data needed as evidence, and then again linking their conclusions back to the questions under investigation. Because the students were in remote classes, the types of discussions using the comics were limited, but in future work there is promise for them to augment the discussions surrounding claims within their data stories, and questions that the data has not yet answered. In some instances, students did frame their questions as questions, and in others we saw the comic integrating assumptions, suggesting that students need more support connecting data to evidence.

6.2 Data Reasoning and Social-Emotional Learning (SEL)

While the **process** of constructing a narrative supported different kinds of data reasoning, the **content** focus on data about teen friendships meant reasoning about the data enacted a variety of social-emotional reasoning competencies such as self-awareness, social awareness, and relationship skills. For instance, in reasoning about how they might be situated in the data, many students engaged in a form of self-awareness, considering the relevant thoughts, emotions, and values and how they influence behavior across contexts. In reasoning about the context in which data lives, students considered related data that might not be in the dataset, yet present interesting connections. For instance, students thought about the historical context of friendship making—who already had friends and in turn might find it easier to make friends? This reasoning, situated within the context of teen friendship data, manifested as a form of social awareness, where they sought to understand the perspectives of and empathize with others, including those from diverse backgrounds, cultures, and contexts. In turn, some students asked themselves—how might racial, gender, or disability aspects of an individual influence their perception of friend making or sustaining friendships? In constructing contexts and considering related data, students engaged in a form of perspective taking, commonly described as a form of social awareness.

Further, the inherent textual and visual components of comics as an art form enabled students' to integrate emotions of their characters through what Lipton and Nowicki [43] referred to as verbal and non-verbal "emotional signals." While verbal signals include recognizing cues that are expressed aloud, non-verbal signals include, *facial expressions, postures, gestures, tones of voice, distance in personal space, rhythm of interaction, apparel,* and *touch* [43]. These non-verbal signals enabled students to express emotional

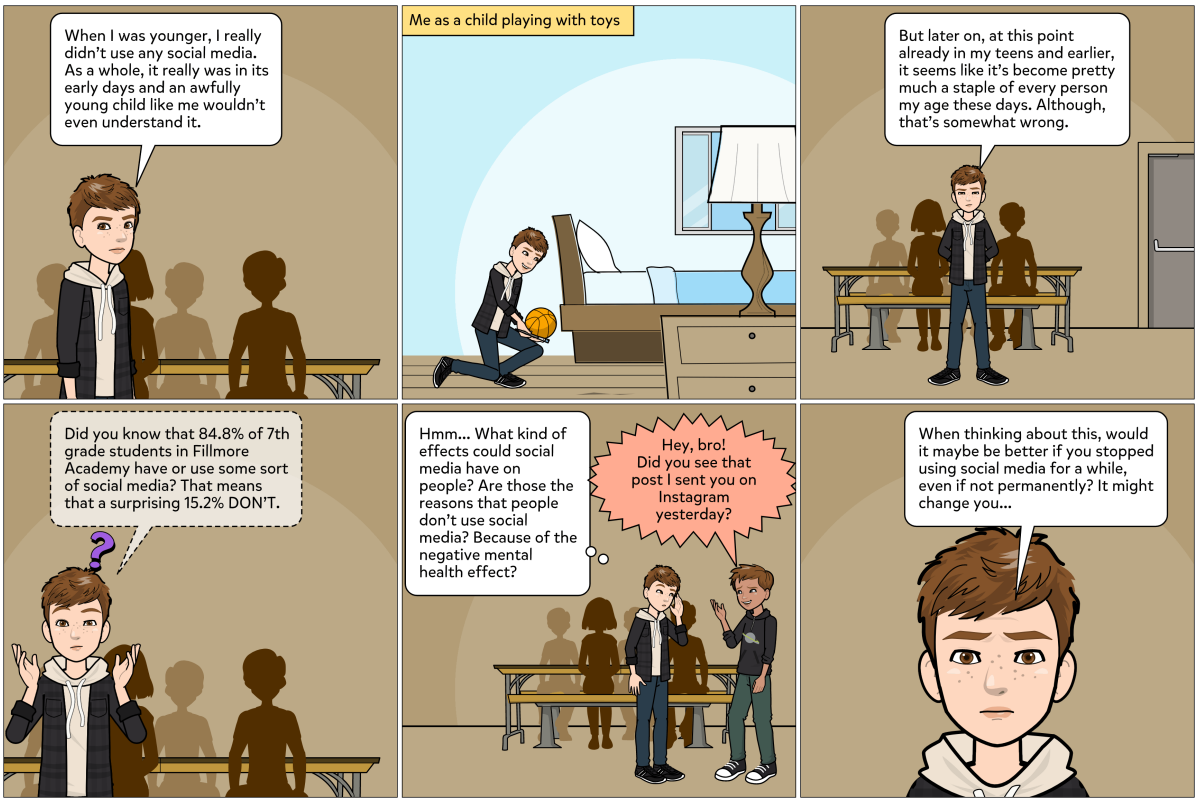

Figure 10: Data comic (C19) on social media use

information of their characters to build the context within their narratives.

Some of our findings suggest that incorporating certain kinds of data literacy skills, such as reasoning about groups or data in the aggregate, might lead to specific kinds of SEL reasoning, such as perspective taking and social awareness. Similarly, situating oneself in the data seems to necessitate self-awareness. The reverse may also be true—that asking students to reason about differences between groups of people might also lead to more sophisticated data literacy skills.

Other forms of data reasoning such as considering the implications of the data many of the students drew on social-emotional components such as self-management and responsible decision-making, which are behavior-oriented rather than purely cognitive or affective. In other words, as students grappled with what the data might mean, their narratives exemplified ways in which the data could be acted upon through actively managing one's emotions or thoughts, or being explicit about making caring and constructive choices about personal behavior and social interactions. This drawing of connections between data analysis, personal contexts, and behavior echoes the work of Stornaiuolo [59] which explores how engaging high school learners in the intentional construction and analysis of data about their everyday activities helped them develop agentive orientations toward data.

In drawing an intersection between data reasoning and social-emotional reasoning we draw connections between a rapidly growing area of interest in STEM (data literacy) and use an art-based approaches to connect to a social-emotional learning. Despite playing a critical role in improving children's academic performance and lifelong learning [63], the integration of SEL competencies into STEM curriculum, rather than as a stand-alone curriculum, remains an area for further exploration. Especially within the current context in which, according to data from the Centers for Disease Control and Prevention's Youth Risk Behavior Survey (YRBS), feelings of sadness and hopelessness and adolescent suicide-related behaviors have significantly increased in the past decade Ivey-Stephenson et al. [34], creating more curricular options that integrate SEL is important. As we seek to draw connections between data literacy and socio-scientific argumentation around topics like climate change [33], so to should we leverage the opportunity to draw data literacy connections with mental health topics that may expand social-emotional reasoning capacities, and in turn support other mental health efforts in schools.

7 LIMITATIONS & FUTURE WORK

In our project the data was made available to the students through graphs prepared by the research team which students could freely explore. While such an approach may minimize technical impediments to creating data representations directly from the primary

data sources (often called "data wrangling" in the Information Sciences; e.g., [36]), it also limits an important component of data reasoning. In what Erickson et al. [22] refers to as "data moves", allowing students to filter, group, calculate, merge, summarize etc., reinforces the non-neutrality concept of data, in that by allowing data to be manipulated, students can reflect on how decisions about data can enable or constrain the types of investigations.

Another limitation of this project were the limited opportunities to iterate on narratives that embody certain kinds of data reasoning. For instance, as students theorized about related datasets, situated themselves in that data and reflected on their own assumptions, cycles of construction and analysis would have helped assess bias and evidence and possibly support more complex data argumentation.

Lastly, there were a variety of statistical reasoning competencies that were not evident in the comics. For instance, probabilistic language in the comics was minimal. Few students compared percentages across groups or used others statistical measures. Future work, may consider providing scaffolded structures that pairs narratives constraints with certain kind of data reasoning to target particular data reasoning competencies. For instance, perhaps prompts to have characters in the comics imagine future scenarios using the data, might prompt probabilistic language and a greater connection with future-oriented SEL competencies like self-management and responsible decision-making.

8 CONCLUSION

As data literacy is increasingly viewed as integral to civic engagement and critical literacies in a technocentric society, the question of how we can move towards a more humanistic and interdisciplinary view of data literacy will only grow in the coming years. Echoing Tygel and Kirsch [62], who draws a parallel between data literacy and the critical pedagogy of Brazilian educator Freire [26], literacy goes beyond just reading words, but about reading the world. A centering of data reasoning connected to argumentation through creative expression can be part of other approaches that seek to build one's capacity to read, manipulate, communicate, and produce data in ways that expose its non-neutrality. Such an understanding can empower learners to develop social understanding and action as they become users, creators, and critical thinkers with data rather than merely subjects of data [18]. As a form of expressive construction [56], art-making can fuse a personally and culturally relevant discipline to data literacy, and invite learners to bring their own interests, experiences and skills to making meaning. Integrating such an art-based approach that centers data on relationships, can connect data reasoning to social-emotional learning in ways we hope will be further explored in future work.

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