Assessing Student Generated Infographics for Scaffolding Learning With Multiple Representations

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Abstract: Student-generated multiple representations are increasingly used in science education, thereby creating a challenge for educators to assess these inscriptions. This paper used student-generated infographics created collaboratively in classrooms where secondary school students were engaged in authentic science news reporting and inductively generated tools for assessing quality infographics in authentic learning contexts. Results showed student-generated infographics can be assessed for dimensionality of the represented topic as well as for representation of understanding. Findings have implication for facilitating learning with infographics and analysis of visual research data.

Keywords: multiple representations, infographics, assessing student-generated artifacts

Lemke (1998) identifies two aspects of science literacy: understanding of concepts and the ability to use multiple representations scientists use to represent and explain a given phenomenon. Accordingly, the ability to use visual representations has become an emerging field of research and practice in science education (Gilbert, 2008). This notion of developing representational competence—the ability to understand, create and critique multiple representations (diSessa & Sherin, 2000) has moved towards using student-generated representations (Van Meter & Garner, 2005) that involves the use of learned representations such as quantitative charts as well as inventive and qualitative drawings.

One of the challenges in using student-generated representations such as infographics—visual representations of data and ideas—is assessing students' work and providing feedback because students often come up with inventive representations that may not have a benchmark. Lack of meaningful support could possibly lead to students' superficial understanding of the concept and failure to understand the relationship between represented phenomenon and the representation. In this paper, we used preliminary analysis of student-generated infographics collected as part of a bigger science literacy project to determine aspects of quality infographics. More specifically, we'll address the question "What are the aspects of quality infographics that teachers can use to assess student generated infographics"? Addressing such issue will help teachers to facilitate infographic-based learning and instruction and foster learners' representational competence.

Infographics as multiple representations

The use of multiple representations in learning and instruction has been a major area of educational research and practice for decades (Gilbert, 2008). Recent attention has moved towards student-generated representations as learning tools and outcomes. Researchers consider student-generated representations to be effective learning strategies similar to summarization and prior knowledge activation (Van Meter & Garner, 2005). An infographic (short for information graphic) is a form of representation of data and ideas often used to communicate with the general public rather than with scientific audience (Gebre & Polman, 2016). It combines the use of quantitative and qualitative data as well as qualitative cues to facilitate readers' understanding of the represented information.

Recent studies show that infographics are increasingly used as learning/instructional tools in secondary school context (Gebre & Polman, 2016; Polman & Gebre, 2015). Although infographics are sometimes referred to as data visualizations implying a visual representation of quantitative data, in the context of our project students often combine up to 4 or 5 types of representations in one infographic and work at multiple layers including the data level, visualization level and the holistic infographic level. By "layers" we mean levels or building blocks students work on in the construction process. The first is the *data* layer where students understand the nature of the data such as quantitative versus qualitative, categorical versus interval data or actual versus proportion data. While the nature of the data they collect depends on the nature and scope of the topic they are working on, students use multiple sources to triangulate their data and determine its credibility. They also organize the data in a way that is appropriate to what they intend to communicate. Polman & Gebre (2015) described how an experienced designer sorted the data when she was asked to create infographics for publication from already collected data.

Data visualization is the second layer. At this layer, students make choices related to determining what kind of visualization helps to meaningfully represent the kind of data they have. For example, pictures and drawings provide physical association with the represented object. Quantitative graphs, on the other hand, do not have physical association with the represented data; rather, they provide insight about the inherent structure of the data that a table cannot provide. Process related data is best represented using a flowchart or schematic diagrams. Semantic maps represent relationships between concepts. Decisions about the type of visualization depends on the nature of the data, the features of the visualization tool and students' understanding of the relationship between the two—data and representation. It is also possible that students can come up with invented or cultural representations which are not taught at school. Thus, this layer deals with appropriate visualization that in turn helps to develop visual thinking and problem solving (Azevedo, 2000; Reed, 2010).

The third layer is the *infographic layer* or the holistic layer. In this case, the infographic becomes a collection of visualizations representing various data and ideas as well as the organization, layout, and qualitative cues of the communication. When working at this layer, students deal with assembling a holistic argument, constructing explanations, organizing sources, and communicating their understanding based on scientific practices of data-driven inquiry (Kuhn, 2010). In addition to the data and organization, students also determine completeness of representation and contextualize it for possible readers.

Assessing student-generated infographics

Formative assessment of students' work and providing meaningful feedback for improvement is challenging in the context of infographic-based learning and instruction. This is so because students often choose different topics to work on thereby leading to the absence of a defined answer or way of doing the infographic. In concept maps, for example, it is possible to use expert-generated map as referent to assess student generated artifacts (Rye & Rubba, 2002). This is because a) often students in a class work on the same project topic in creating the concept map and b) it is relatively easier to create concept maps by experts in the field that can serve as a benchmark. Infographics are used as both learning and communication tools in the context of science literacy where students choose different topics that make sense to them or their community. One of the teachers in our project memorably said "it is easier for me to let students choose their own project topic and then support them in finding the data they need rather than choosing a common topic for all students and then working on their motivation". The challenge with this approach and infographic-based instruction is the absence of guideline for assessing student-generated artifacts. This is also a challenge in general areas of student-centered instruction especially when student-generated artifacts are in visual forms. In this paper we use 30 student-generated infographics and analyze them inductively to come up with aspects for quality infographics.

Project and methods

STEM Literacy through Infographics (SLI) is a design-based Development and Implementation project (DIP) funded by the US National Science Foundation (NSF). The project focuses on developing young adults' (grade 10 to 12) science literacy, mathematical reasoning and representational competence through actively engaging them in a collaborative process of creating data-driven infographics for authentic online publication on http://science-infographics.org. This DIP is a continuation of a two-year exploratory project and currently involves five traditional secondary schools, one alternative experimental secondary school, one after school program and one summer program in three states in the US—with a total of 1084 participating students. Data used in this paper was collected from two sites in a large metropolitan area in the Midwestern United States: a suburban public secondary school with socioeconomically and ethnically diverse population and an after school internship run at a mid-size private university. What students do in the project is described in detail elsewhere (Gebre & Polman, 2016). However, we briefly described it here to provide context. In face-to-face classroom context, students work in pairs or individually on a) identifying a science related topic to work on, b) searching for relevant data from online sources and databases (e.g., the Centers for Disease Control, National Institute of Health, Environmental Protection Agency, etc.), c) organizing the data and creating infographics, d) providing peer feedback using online collaborative tools (e.g., VoiceThread), e) getting feedback from an external editor who is the curator of the online publication website and member of the project (with PhD in Chemistry) and f) revising the infographics and submitting for publication. The data used for this paper are draft and final versions of 30 infographics produced by participating students in one of the six schools.

Data analysis involved openly comparing student-generated infographics and identifying the similarity and/or differences between them. The author used six infographics (that were not part of the 30 analyzed here) and compared them with the purpose of delineating features where infographics differ or align. He then developed a rubric with eight dimensions to determine quality of infographics. Two research assistants reviewed the dimensions at different times and provided comments for improvement based on their analysis of the infographics. Both students reported challenges of using the eighth dimension ("parsimony") as it became too subjective to assess. We then dropped "parsimony" and scored five more infographics using the rubric. This was followed by discussion of the scores. One of the research assistants and the author scored another six infographics and discussed their results. We then coded the draft and final versions of the remainder of the infographics.

Findings and discussion

Results showed student-generated infographics can be assessed in terms of seven features listed below

Types of representations. Infographics vary in terms of the various forms of representations they have (icons, bar charts, drawing, non-label text). Some infographics have just one visual representation while others have as many as five types.

Distribution of information. A related feature is whether information is distributed over different types of representations or are students repeating the data they presented in one form to another form. That is, the repetitive versus complementary nature of the data presented in various formats.

Dimensionality. Some infographics are rich in terms of content and others not so. Dimensionality relates to how many aspects of the represented topic are addressed in the infographic. It has to do with the depth, richness or completeness of the infographic to communicate the intended purpose or to tell a story.

Nature of data. In the context of our project, infographics are tools for students to make data driven arguments about the topic they are interested in. The question then becomes what kinds of data are students including in their representation (e.g., raw or proportional data, quantitative or qualitative data)

Contextualization. Most of the students pick project topics based on whether or not the topic is relevant to them or to someone they know—what we call "personal context" to the project. For example a student chose to work on "cauliflower ear" because he is a wrestler and has experienced the problem personally. The question is whether such context is communicated to readers through the infographics. Is there enough contextualization for readers to understand what the infographic tries to communicate or why it matters? Are readers able to answer "so what?"

Correspondence or alignment between various parts. This criterion includes both conceptual and technical alignment between various elements of the infographics. For example, does the title represent what is represented in the body of the infographics? Is the use of colors and shapes consistent through out the infographics?

Sources. Are there multiple, credible sources for the data and claims represented?

Each aspect discussed above was scored out of 3 points using the rubric. Our purpose was not to focus on the numeric value of the scoring, rather on the qualitative improvement of each infographic (and the representational skills of the learners) from the draft to the final version. We focused on the continuum nature of the scoring that range from 1 to 3 to represent low, medium and high quality work, respectively.

Figure 1 presents the average score for draft and final versions of the 30 infographics. The highest scores are for "distribution of information" and "sources" both in the draft and final versions, implying a) students do not use repetitive representations or they use different kinds of tools to represent different aspects of their topic/data, and b) they provide multiple credible sources for the information they include in their infographic. Figure 1 also shows that complexity of representation (dimensionality), which has to do with "completeness" of the representation, has the least score both in the draft and final versions. Based on our classroom observation, this happens because students sometimes perceive infographics as creating one quantitative chart as opposed to making a complete argument or story.

The use of multiple representations is the hallmark of scientific reasoning and explanation (Lemke, 1998; Gilbert, 2008; Yore and Hand, 2010). Our findings build on diSessa's (2002) work on representational adequacy of student-generated representations and the Polman & Gebre's (2015) work on framing infographics as scientific inscriptions. It also extends prior work by inductively generating features of quality infographics. We'll build on this preliminary analysis to help educators and students who use infographic-based learning instruction in their classes. From a research perspective, our existing and future analysis contributes to understanding cognitive aspects of infographic-based arguments and visual methods in research data analysis.

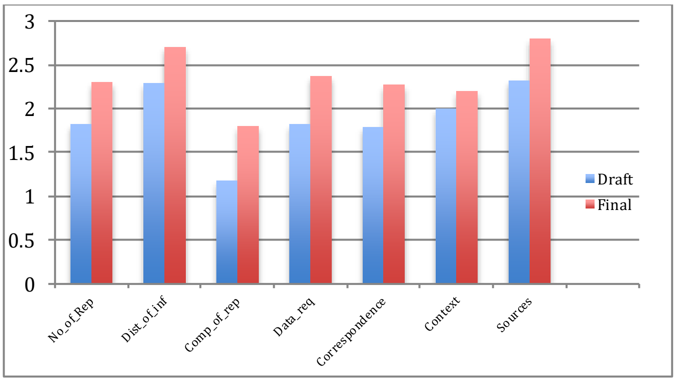

Figure 1. Average scores of draft and final version infographics (N=30).

The use of multiple representations and semiotic tools is necessitated by the demands of the science curriculum (Lemke, 1998; Yore & Hand, 2010). Infographic serves as a learning tool and uses multiple forms of representational tools. Accordingly, assessment of student-generated infographics needs to address both the content and the representation aspects of learning. This study helps teachers who design learning with infographics to consider these two main aspects while assessing students' work.

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