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Creation of data visualization and synthesizing process

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Keywords:

Communication, creative process, data visualization, design, infographics, synthesizing skills, visual literacy, word cloud.

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Abstract:

Synthesizing skills are in high demand in the 21st century. Educators believe the synthesizing process goes hand in hand with creativity. As a synthetic communication tool, data visualizations such as infographics and word clouds can effectively convey complex information in simplified visual form. Examining samples of data visualizations made by college students, this paper will investigate the relationship between the creation of data visualization and synthesizing skills, as well as address how the creative process of data visualization coincides with synthesis. This study finds that the process of making a data visualization requires students to utilize their critical thinking strategies, prior experience, knowledge across curricula, and abilities to thin- slice, decode, and comprehend visual images.

1. Introduction

In predicting what skills may be needed in the 21st century, a number of scholars agree that synthesizing skills will be crucial. A person with a synthesizing mind (Gardner, 2010) has the ability to survey a wide range of sources, pinpoint important elements, and present the information in a way that is interesting. Gerver (2012) highlights synthesizing skills as the key to managing information and developing a range of techniques for accessing, evaluating, and differentiating information. He stresses that they help students to achieve high standards in literacy, numeracy, and spatial understanding. In addition, synthesizing skills can enhance students' abilities to handle information communications technology and understand the messages that underlie the information.

Data visualization, a visual tool used predominately in science and business, is now receiving attention in the field of education (Chandler, 2004; Linn et al., 2006; Segel & Heer, 2010; Davis & Quinn 2013). In part, I believe, this rising interest in the United States is the result of focus on programs where disciplines such as science, technology, engineering, arts, and math (STEAM) are connected and integrated closely into everyday teaching. In addition, teachers are encouraged by current teaching standards (e.g., the Common Core English Language Arts Standards) to use different media or formats to help students develop a coherent understanding of text and further convey their ideas. To promote artistic literacy in a digital age, the latest U.S. National Coalition for CORE ARTS Standards (NCCAS) has included media arts as a fundamental skill for students, believing that media arts enable them to "relate artistic ideas with social, cultural, and historical context," to "synthesize meaning and form cultural experience," and to "relate to various contexts, purposes, and values" (NCCAS, 2014). In response, I argue that more educators should use data visualization as a tool that can help students to transform complex knowledge into simplified visual forms. A few questions are suggested by the increase in the importance of synthesizing skills and the use of data visualization: What is the relationship between the creation of data visualization and synthesizing skills? If synthesizing skills shape the foundation for creativity and build competency in managing information, does that imply that there are some common or complementary threads between the creative process and the synthesizing process? If so, what role do synthesizing skills play in the creative process? Does the synthesizing process feed creativity, or vice versa? In addition, what role does data visualization play in obtaining knowledge? Lastly, can the creation of data visualization provide long-term effective knowledge, knowledge of a more permanent nature?

2. Methodology

This article attempts to address these questions by examining samples of data visualizations made by college students in two recent classes of mine. I will first investigate the relationship between the creation of data visualization and synthesizing skills. Then, I will discuss how the creative process of data visualization coincides with the synthesizing process. I collected two sets of data visualizations (Infographics) created by students at Washington State University Tri-Cities, USA. One group of students was education majors who enrolled in my integrating arts curriculum design course in the spring of 2014. The other group who came from diverse academic backgrounds, mostly in the field of science and engineering, were taking an art history survey course with me. They were familiar with basic computer technology, including the use of social media and possessed some basic skills in digital image alteration. I introduced two online basic visualization tools for students to consider–www.easel.ly and the word cloud generated by Tagxedo.com. These tools provided enough visual elements for them to explore and are user friendly. In addition, both websites offered easy-to-follow tools to create infographics, using pre-set templates and also allowing users to create their own design.

The students were assigned to investigate several research questions. The Education majors were asked to focus on conflicting issues from American history. They had to pinpoint concealed stories to promote social justice. On the other hand, each student from the art history group investigated the iconography of a specific artifact. Even though the groups worked on different topics, they involved the same procedure: researching the topic, comprehending a body of text, synthesizing the knowledge, and transferring the knowledge into a visual form. This procedure was the main focus of my investigation, in which I was seeking to understand in more detail the skills that the creation of data visualizations calls on. In the study, a total of 35 data visualizations were collected. Besides their data visualizations, the data also include students' design statements and answers from an open-ended survey on their data visualization experience. In analyzing the survey data, each sentence was treated as a unit to be coded. Even though the frequency of words was taken into consideration when finding patterns and themes, the coding of each unit was determined by its meaningfulness and relevance to the question. As Stribos et al. say, "the meaningfulness of a statement should not be determined by [pre-set] coding categories or (a researcher)" (Stribos et al. 2006, p. 33). The findings then served as categories to examine 35 visualizations and pinpoint reoccurring patterns and themes in them.

3. What is the synthesizing process?

Before significant correlations between synthesizing skills and the creative process of data visualization are discussed, it is crucial to define what I mean by 'synthesizing process.' People often associate synthesizing skills with reading and writing; however, synthesizing skills are utilized daily. For example, imagine that we are at a dinner table, recalling an exciting event. How do we start the conversation? In our mind, before and during our talk, we form anchor points to help guide the conversation. These are the anchor concepts or key mental images that will later prompt the creation of a lengthier descriptive account to complete the retelling of a specific experience or story.

This process is similar to a reflective strategy, where we discuss the importance of content by dissecting the learning process into segments. The synthesizing process requires recall, analytical skills, summarizing, organization skills, a sense of reasoning, and order. The synthesizing process is able to demonstrate each individual's decision-making strategies and how they would transform a complex body of information into simplified but meaningful and interesting content for the audience.

Even though synthesizing processes utilize analytical skills, it is important to differentiate between them. As Takeda, Tsumaya, and Tomiyama (1999) noted,

> *The aim of analysis is to clarify characteristics of objects. To clarify objects means to explain different objects in the same manner... The characteristics should be universal and minimum. This implies that*

requirements for knowledge for analysis also include universality and minimality. On the other hand, the aim of synthesis is to create objects having necessary characteristics... In order to capture human desire for objects, characteristics should be as rich as possible to represent various desires. Thus requirements for knowledge for synthesis are not universality and minimality but rather individuality and diversity. (p. 9-2).

Synthesizing also involves the application of summarizing skills to highlight the content in an abbreviated format; however, synthesizing is different from summarizing. Summary involves sequence and logic, and its intent is to present the content in a brief format. It requires abilities to make judgments of importance and to organize, but. To some extent, summarizing is similar to synthesis, requiring skills such as recalling and reflective strategies; however, its format is not as flexible as that of synthesis, which is able to weave in personal input and interesting detail at the same time. And these details are often important if the data visualization is to be interesting as well as informative.

4. The relationships between data visualization and synthesizing process

I believe the creation of data visualization shares a process similar to that of synthesizing, as mentioned previously, where meaningful decisions are made to convey certain messages. The role of data visualization is to communicate ideas effectively and make thinking visible. According to Few (2007), "Data visualization is not about making things look cute or pretty. It is not about dressing up your presentations to dazzle your audience... it mostly involves science, a set of rules based on what we know about visual perception and cognition, which we can follow to display information effectively" (p.9). To do this, one needs to know how to use design principles to present an idea in its complexity. Thus, I believe that the creation of data visualizations also requires a certain understanding of aesthetics and design.

Viewing data visualization (infographics and word clouds) as a thinking process similar to those of writing and reading, Davis and Quinn (2013) believe that infographics should include several elements that assist students to comprehend information:

1. Purpose: The audience should be able to infer the author's purpose, draw conclusions based on the evidence, and summarize the gist of the infographics.
2. Style: The graphic components, including the layout, text, symbols, and color schemes, should address the tone of the author.
3. Evidence: Data and text must be cited and appropriately integrated into the design to support the reader's understanding.
4. Format: The infographic can be represented in a static format, designed for print, or a dynamic format allowing interactivity.

5. Results: The creation of data visualization stage one: reduce and thin-slice

From my analysis of the data I collected from students - their data visualizations, design statements, and open-ended survey answers – I think the process of creating data visualization involves three stages: 1) reduce and thin-slice, 2) reflect and connect, and 3) recreate and emerge.

This fundamental stage aims to distill the information, maintaining only the critical information. According to Gladwell (2007), "thin-slice refers to the ability of our unconscious to find patterns in situations and behavior based on very narrow slices of experience" (p. 23). Gladwell appears to refer to the brain's ability to subconsciously make decisions and arrive at conclusions based on intuitive decision-making skills. Thin-slice is used to describe how students pinpoint key concepts and represent them in a simple visual form extracted from a complex body of knowledge; and how they balance their intuitive snap judgement with their deliberate thinking, which is assisted by the internet and textbooks. To achieve this goal the students had different approaches. While some students listed out keywords, after digesting their readings, many students started the process by separating the information into sections and reducing the information based on whether the information was relevant to the questions.

As one student revealed, "In order to create a coherent visualization project, I started with a main idea rather than seeking general information and finding a way to piece the tidbits together. Everything that was included in my visualization supported that main idea. Anything unnecessary was cut from the project. This allowed me to expand both visually and in written word on a single message that I wished to communicate to the viewer" (Student A, personal communication, May 6, 2014). In our daily experience, we tend to provide details and examples to better illustrate an idea.

This project certainly challenged students to provide enough information in the limited space to create effective data visualizations. As a result, finding what is important and what is meaningful from text is often challenging. One student reflected, "Most of what my project comes from is just throwing a lot of knowledge out [i.e. data reduction]. Frankly, I like a lot of info in my presentations and so it was difficult for me to know what to get rid of" (Student B, personal communication, May 6, 2014). Another student expressed, "I would take only the minimum of what is necessary for the understanding of what I am trying to get across. It is easy to get wrapped up in so many details, but they are usually something the audience doesn't need. Getting across the main points is important and [one] can get lost in too much information" (Student C, personal communication, May 7, 2014). Importance and relevance are two factors students use to thin-slice a body of text. Students achieve this by abandoning detailed descriptions. Instead, they learn to distill the data down to the most crucial information. This is evident in creating a word cloud. For example, in Figure 1, Lisa listed out important figures, events, times and places to retell the story of the Trail of Tears, recounting the removal and displacement of the Cherokee tribe following the Indian Removal Act of 1830. In a quick glance, the audience can understand some fundamental information related to this piece of history. The words presented in the word cloud, even though fragmental, help the audience to obtain the scope of the story when they are woven together. For readers who do not know the history, these words act as a guide with points of interest for further research.

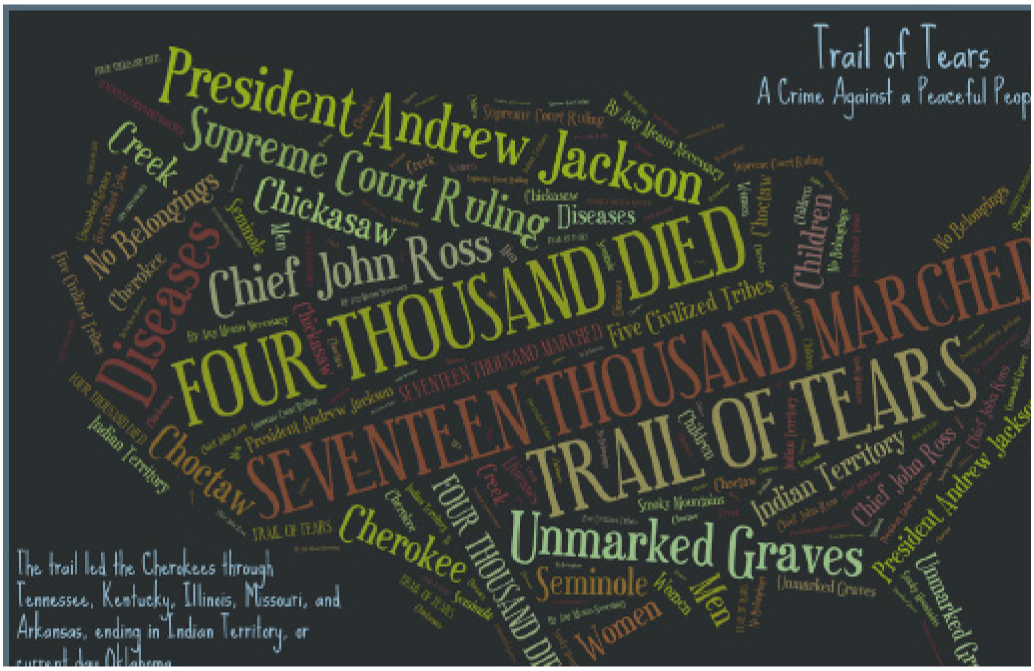

Figure 1. Trail of Tears, by Lisa Smith, via Tagxedo.com.

Another example illustrates distinguishing features from representations of the Buddha in early Buddhism (Fig. 2). Corey, the creator, first selected important iconographies such as the Great Stupa at Sanchi, the lotus, the Bodhi tree, and the footprints, to represent Buddha's various states of existence. Corey then began to realize that the existence of the axis mundi actually plays a vital role, so he purposely created images to emphasize the axis mundi as the cosmic order, "Each of these iconographic images contains an axis mundi, which I tried to emphasize by splitting the images in half and using both Tagxedo and real images." Indeed, these split images make the concept of the axis mundi apparent and as the essence of this data visualization.

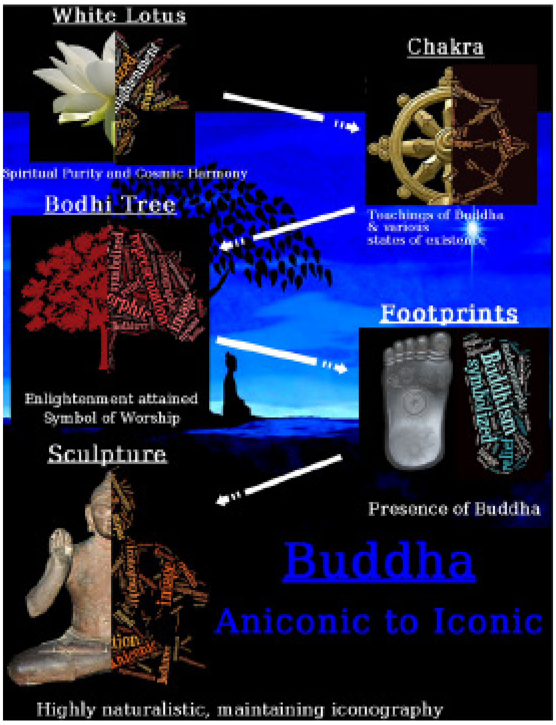

Figure 2: Buddha: Aniconic to Iconic, by Corey Kincaid, using both Tagxedo.com and easel.ly.com

6. Stage two: Reflect and connect

In the reflect and connect stage, the creative process involves making meaningful connections. This includes connecting to visual readers as well as prior knowledge. Many students admitted that keeping the readers in mind helped them keep the information concise and avoid misrepresentation. They acknowledged that data visualizations need to communicate with the audience. As one student pointed out, "You have to think about what people's initial perceptions are going to be when they see your visualization" (Student D, personal communication, May 6, 2014). Prior knowledge influences the design during the creation process. Many of the designs and content of the data visualizations reflect the students' knowledge from other disciplines. Having experience in art, managing data, writing, teaching, or, as one student reported, decorating cakes helped them to think about and create data visualizations from different perspectives.

The creator also needs to consider the audiences' prior knowledge. This is apparent when utilizing symbols and metaphors in the design. The creation relies upon the creator's spatial ability and perception to apply specific spatial metaphors (Lakoff & Johnson, 1980) to achieve a sense of flow in the information process. These spatial metaphors are rooted in design and are greatly influenced by physical and cultural experience (Reed, 2010). For example, the design of a flow chart is based on our understanding of a path metaphor. As seen in Figures 2 and 3, the use of arrows in the design helps visual readers to navigate and comprehend the flow of the visualization. The placement of the horizontal black line in Figure 3 cuts the composition in half. According to Michael, he intentionally designed it to prepare readers to navigate through the various sets of information. The choice of symbols affects audiences' perception and understanding of the abstract concepts that the data visualization is conveying. For example, when choosing a symbol for Mycenae, Michael used bricks to represent a fortress-like city (Fig. 3). In contrast, he uses the column-style structure for Knossos. By doing so, he assumed that his visual readers will be able to make the connection and distinguish the differences between these two styles.

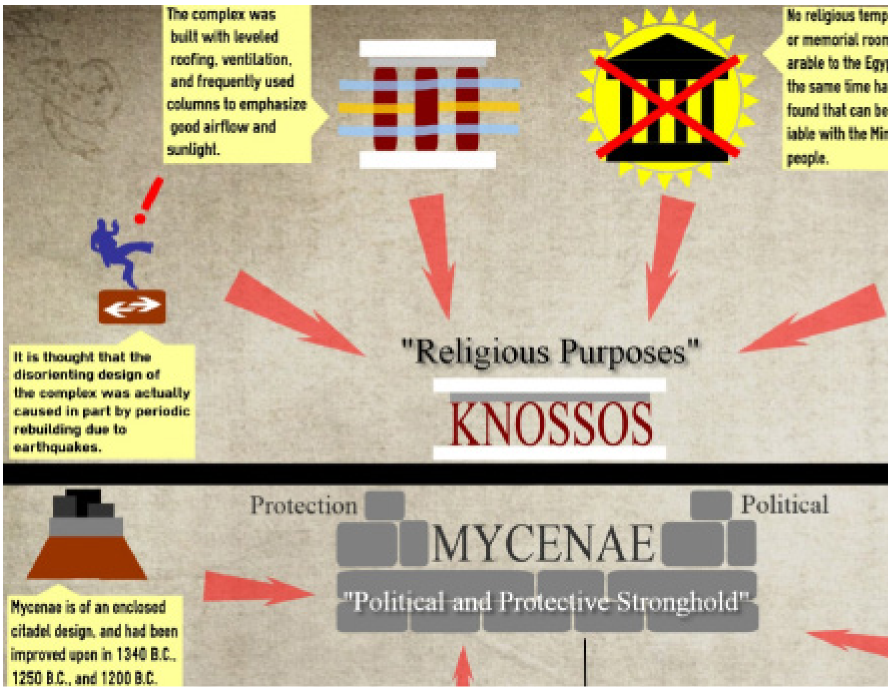

Figure 3: Knossos and Mycenae by Michael Kelly, via easel.ly.com.

Indeed, the synthesizing process is knowledge-based. It requires activities such as brainstorming, recalling, and adapting to apply and transform knowledge into a new form. The new form could be a transition point, where knowledge leads or links to another finding. Such processes can be translated into a creative process, where creators experience how ideas take root, transfer, and transform into visual elements in order to communicate with the viewers; however, this new form does not happen without some basis of familiarity, which is derived from and accepted by shared experiences. A sign, a metaphor, and certain text all carry possible connotations that draw upon common experiences. Utilizing these visual signifiers instantly provides effective communication between the designers and viewers. Thus, the challenge of creating something new depends upon an individual's interpretation of these visual signifiers in a different light.

7. Stage three: Recreate and emerge

To create the data visualization is to recreate from what has been condensed. Students' thinking strategies reflect senses of order, sequence, and logic; they wish to create a balance between text and images. This creative process requires constant adjustment and evaluation to assess whether the data visualization conveys the idea. And sometimes, the process becomes a quest for innovation.

Figures 4-7 are four versions made by Terry to illustrate the differences between the Pantheon and the Hagia Sophia. According to him, the structure of the dome is the center of the research. Therefore, in his earlier versions (Figs. 4 and 5), word clouds were made to highlight the key characteristics of the two. Frustrated by the outcome, he began to seek a new style to present (Fig. 6). He eventually included images of the objects from his desk to juxtapose different materials used between Pantheon, the Hagia Sophia, and modern day. The new result is dramatically different from what previous versions presented; yet, it provides crucial information with a unique personal presence (Fig. 7).

Figure 4: Pantheon and Hagia Sophia (Version I) by Terry Sunghoi Jung.

Figure 5: Pantheon and Hagia Sophia (Version II) by Terry Sunghoi Jung.

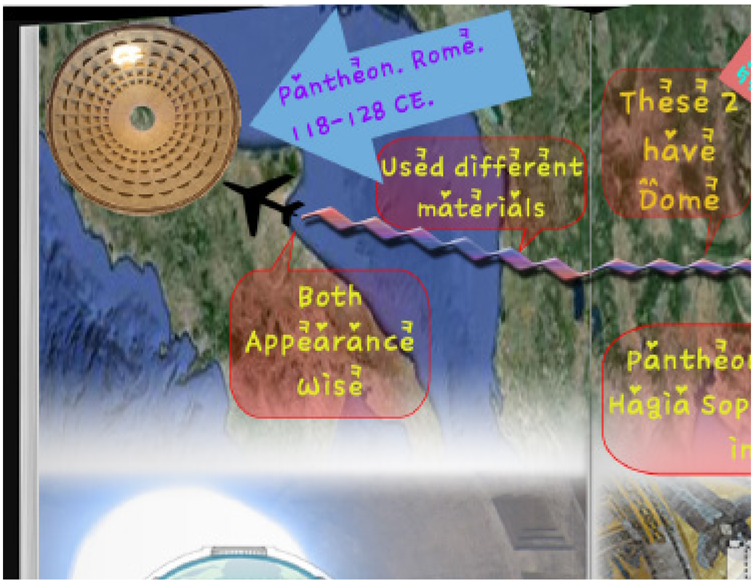

Figure 6: Pantheon and Hagia Sophia (Version III) by Terry Sunghoi Jung.

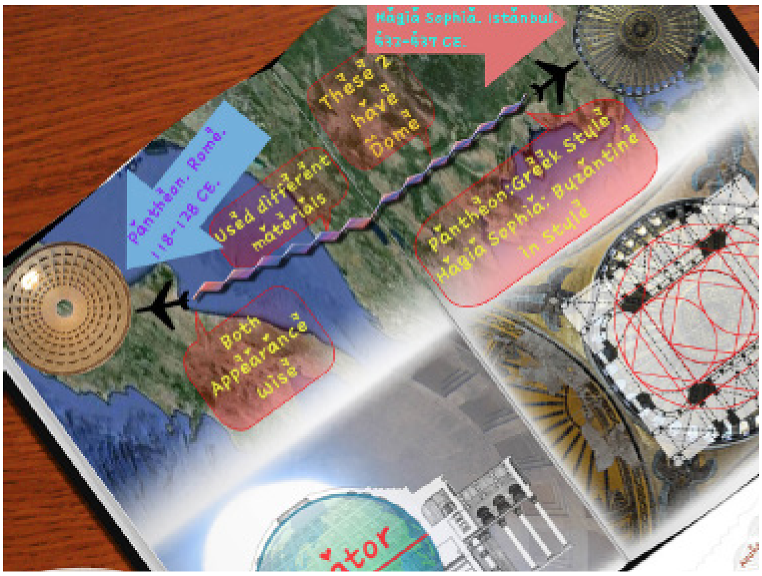

Figure 7: Pantheon and Hagia Sophia (Version IV) by Terry Sunghoi Jung.

8. Conclusion

The outcome of this study revealed that synthesizing skills and the creation of data visualization share common threads, where information-based knowledge is being clarified, refined, and recreated into a communicative format. From my analysis of the students' experiences, I believe the creation of data visualization is a form of synthesis, requiring three processes: reduce and thin-slice, reflect and connect, and recreate and emerge. It compels creators to make acute judgments, integrate disciplines, multi-task, and be innovative and diverse in order to effectively communicate the desired message. The results portray that synthesizing skills and the creative process of making data visualization interact with each other, forming collaborative relationships. However, the results also demonstrate how students' synthesizing skills and creativity may be restricted by the availability of data visualization generators and what format of design and creative freedom these generators offer. In the case of using preset templates to create word clouds, the creative process is limited to making decisions on selecting shapes, fonts, color, and orientation to fit the content. Some students mentioned that using these preset generators may save time to complete the project but also limited how they could express their idea. The synthesizing skills were used to fit the format, and may or may not represent the students' creativity. Teaching with multiple modalities in accord to students' diverse learning habits has become a way to promote effective teaching and learning. Using unconventional teaching materials such as data visualization is a way to embrace learners who prefer such an information process style. Many scholars recognize the combination of texts and images may promote deeper processing of information (Chen & Fu, 2003), maintain learner attentions (Shah & Freedman, 2003), and help fluency in art and information technology (Peppler & Kafai, 2005; Peppler & Kafai, 2008). It is important to note that making of data visualizations provided opportunities for my students to better understand their research topic by becoming visual creators. Because they were responsible for creating a better medium for communication, the quest for a good visualization motivated them to research more, synthesize further, and evaluate harder. Many admitted that making data visualizations was certainly a very challenging but rewarding experience compared to writing a term paper. They recognized that the creative process helped fine-tuned their synthesis skills to streamline text, images, and designs. In the wave to promote media arts and visual literacy, data visualizations may become the means for communication for both educators and learners. In addition to the needed technical knowledge, the design of data visualization needs to be visually appealing to entice viewers. In the quest to blend old (facts and existing knowledge) and new (new knowledge and forms), and uniquely marry data (text or numeral facts) and images, data visualization becomes a meaningful form of communication for students to reflect on and refer to. Undoubtedly, this form of communication helps transition the learners from visual receivers to become active contributors and creators. I believe data visualization is beneficial to cultivate students' synthesizing skills, connect knowledge, and promote visual literacy; but, at the same time, there is a need for further research on itslimitations, its impacts on students' creativity, and its implications for long-term effective learnings.

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