**Literature Review**

A DataStoryTM is a unique learning experience, a combination of storytelling, comic book visual learning, literate programming, and pedagogical best practices. Each of these four elements is supported by established bodies of literature, and the contribution of each is discussed in the sections which follow.

*Storytelling*

The use of educational stories is not new. Harvard University’s business and law schools first introduced stories (case-studies) into their curricula some 100 years ago. Indeed, the case study can be thought of as a special kind of story, narrative designed to build reasoning skills while also imparting content. Herreid (1997) writes, “Cases are stories with a message. They are not simply narratives for entertainment. They are stories to educate” (p. 92). As such, the story has proven to be an effective pedagogical tool.

There is a substantive and growing body of literature that describes how to develop and use case-studies in science teaching. Clyde Herreid (2007, 2012) – the founder of the *National Center for Case Study Teaching in the Sciences* – has been especially active in this space. (The center’s website features some 780 case-studies available to registered faculty.) Herreid’s articles and edited volumes are thus foundational and provide a practical introduction to the art of case-study construction and teaching.

About a dozen articles in science-related journals have reported positive learning outcomes related to the case-study method (Harman et al., 2014; Grunwald & Hartman, 2010; Rybarczyk et al., 2007; Chaplin, 2009; Nair et al., 2013; Wilcox, 1999; Bonney, 2015; Yadav & Beckerman, 2009; Bjorn et al. 2013; White et al., 2009). Only Yadav, Shaver, and Meckl (2010) reported “no significant differences between traditional lecture and case teaching method on students’ conceptual understanding” (p. 55). Even so, they still viewed case-studies in a positive light, given their ability to actively engage students in the learning process. Faculty also appreciate the benefits of case-studies as learning tools. Yadev et al. (2007) conducted a national survey of faculty perceptions of the case-study method and found that a majority reported positive outcomes when using this method.

Much of the research in this space has yet to consider the role of emotion in the learning process or its place in case-studies. For example, Herreid (1997/1998) does not explicitly mention emotion in his list of criteria for writing a good case, though one of those criteria is that good cases arouse empathy for the characters featured in them (p. 163). The conceptual model advanced by Kim et al. (2006) does not list emotion as a core attribute of cases. Neither does it appear as a response on a survey conducted by Herreid, Schiller, Herreid, & Wright (2012) where 1,300 faculty were asked, “What are the attributes of your favorite cases?”

*Comic Book Visual Learning*

*Literate Programming*

*Pedagogy Best-Practices*

Educators have long recognized that motivation and engagement are key drivers of student learning. Achieving either, however, entails some level of emotional involvement on the part of the student. Richter-Levin and Akirav (2003) have investigated the relationship between emotion and learning at the neurological level. Emotional Tagging is the phrase they use to describe this process. What they discovered is that the amygdala tags emotionally charged experiences which, in turn, enhances the formation of long-term memories. It does so by strengthening the synapses of neurons activated by emotion arousing learning events.

The importance of emotion in the learning process has received increasing attention in the literature (Herreid et al. 2014).

The article by Young and Anderson (2010) is especially relevant in this context.

*The Case-Study and DataStory Contrasted*

Although a DataStoryTM shares many commonalities with case-studies – content in both, for example, is packaged in a story container or narrative arc – there are important differences as well. With data stories, the focus shifts to data analysis and/or the acquisition of the requisite technical skills to conduct data analysis. This is not true of case-studies where data may be present but is rarely the focus.

Interactivity is another feature of DataStoriesTM that distinguishes them from the traditional case-study. The case-studies featured at the National Center for Case Study Teaching in Science website, for example, are offered in static containers – MS Word, PowerPoint, or Adobe. A DataStoryTM, on the other hand, is developed with open source tools such as [RMarkdown](https://rmarkdown.rstudio.com/) or [Jupyter Notebooks](https://jupyter.org/). With these technologies, students can interactively run blocks of code and receive immediate feedback. Learners can also modify blocks of code to fit their needs and/or analyze similar kinds of data sets. In other words, these tools support dynamic, interactive learning experiences with feedback in real time, making them ideal learning tools for novice and experienced learners alike.

A defining feature of a story-driven approach to data science education is the innovative use of visual and video learning modalities in combination with narrative, data, and code.

And finally – rather than present technical skills in isolation – the DataStoryTM approach contextualizes the learning experience. That is, concepts are not illustrated by way of abstract examples. Rather, they arise naturally from within the story itself.

*Design and Methodology*

The foundational question of this research study asks, “Does the data story method of instruction engage and motivate students to a greater extent than traditional methods of instruction?” The typical data science learning experience today, either in-person or online, adheres to the traditional lecture format. A knowledgeable instructor lectures from the front, often demonstrating the features of a software program written in R or Python. The Carpentries advocate the use of “live coding” as it demystifies the art of programming, frequently giving students the chance to view a knowledgeable instructor making coding mistakes and recovering from them. Data Camp – a popular online data science learning environment – presents content in a similar fashion, with instructional lectures discussing a particular technique or concept, interspersed with interactive coding exercises.

The initial set of research questions to be investigated are listed below.

The research team plans to employ a mixed methods approach to address these questions and others which arise during this preliminary investigation (Creswell, 2014). The information gleaned from this work will also be supplemented by a pre-and-post survey. Research methods inspired by phenomenology will be used to investigate the cognitive psychological dimensions of the data story instructional method (questions 1a – 1d). The research executed in response to these questions will be informed by the methods of classical phenomenology (Van Manen, 1990; 2016), phenomenography (Marton, 1986), and protocol analysis (Ericsson & Simon, 1993; Fonteyn, Kuipers, & Grobe, 1993).

[Usability testing](https://en.wikipedia.org/wiki/Usability_testing) data will be collected in order to evaluate the Data Story Method of Instruction from the perspective of study participants (questions 1f & 1g). Data collection will be informed by a mental model theoretical framework (Jonassen, 2001) and implemented using the DECIDE framework (Rogers, Sharp & Preece, 2011). The DECIDE framework involves a six-step process to evaluate a prototype's capacity to address its design and development goals. The goals for usability testing will include: a) participant’s perspective on usefulness, satisfaction and ease-of use, and b) usability issues (e.g., problematic behaviors, frustration, misinterpretations). We will use pre and post surveys and interviews to analyze study participant expectations and how these goals and expectations are met as a result of the data story way of instruction.

*Notes*

We love the tangible, the confirmation, the palpable, the real, the visible, the concrete, the known, the seen, the vivid, the visual, the social, the embedded, the emotionally laden … Most of all we favor *the narrated.*

Alas, we are not manufactured, in our current edition of the human race, to understand abstract matters – we need context (Taleb, 2007, p. 132).

If I have a set of 200 random variables, completely unrelated to each other, then it would be near impossible not to find in it a high correlation of sorts, say 30 percent, but that is entirely spurious (Taleb, 2012, p. 418).

At the neurological level, Richter-Levin and Akirav (2003) have advanced the Emotional Tagging concept. They suggest that the “amygdala ‘marks’ an emotionally charged experience as important by strengthening of synapses located on neurons that have just been activated in another brain-memory system engaged in the learning situation” (p. 248).

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