Iterative Curricular Design of Collaborative Infographics for Science Literacy in Informal Learning Spaces

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Abstract: This short report describes the design and implementation of a two year, iterative curriculum developed to promote science literacies through the creation of news infographics in an informal learning environment. Paid, high school student interns were recruited to identify an issue of personal and social relevance and create infographics that visually represented and communicated the science behind their topic. After several cycles of peer and editorial review, these infographics could be published in an online newsmagazine. Three cycles of data journalism activity with distinct participation and activity structures are described, with considerations of the affordances and constraints of each cycle.

Keywords: STEM literacy, data visualization, designed learning environments, informal learning spaces

Introduction and purpose

The central research question of this two-year study asks, "How can the collaborative critique and construction of infographics using cyberlearning technologies be organized around data journalism practices in learning communities to foster high school students' science and data literacy?" After conducting background research considering how experts make sense of published science infographics (Polman et al, 2015) our team designed and implemented two science infographic learning spaces for high school age students. The learning environment we concentrate our attention on here consisted of a small group of students (approximately ten) who were employed as student interns at a Mid-Western university in the Unites States. These high school interns were paid employees tasked with designing, creating, submitting for review, editing, and ultimately publishing science news infographics of their own choosing. Over the two years that this data journalism internship occurred, we identify three distinct cycles demarcated by specific lessons plans, expectations of students, technological scaffolding, instructor and editor involvement, and ultimately infographic artifacts published by the students. We concluded that though each cycle has particular affordances and constraints, later cycles proved most effective at enabling students to thoroughly engage, digest, and make relevant complex scientific data through the creation of publishable infographics. This short article offers reflections on the iterative design and implementation of this curriculum, with some considerations for future directions

Perspective/Theoretical framework

We frame our review and analysis of the data journalism internship in consideration of a framework of "contextualizing science in life" (Polman, 2012). Each cycle of the intern infographic curriculum began with students making personal connections to science data in their own lives and expanded towards broader social relevance and communication of complex information to the public. The diverse backgrounds and prior trajectories of identification interns bring to the site greatly inform and validate this engagement (Polman, 2012). In this sense, student interns were positioned not just as learners, rather they were active practitioners and conveyors of complex science knowledge (Wenger, 1998). As these paid interns were treated as employees, they entered into and helped define a community of practice (Lave and Wenger, 1991). Through their active participation, independent work, and multiple cycles of peer feedback, student interns helped create and define an informal space where they worked (Polman et al, 2014). These interns had the opportunity to increase their statistical literacy through the use of large scientific data sets (Hammerman, 2009).

Methods and data sources

Our method is an in depth case study of the high school data journalism internship that occurred 2012-2014. Primary data consist of lesson plans, research team meeting minutes, film and activity logs of student work time, student time sheets, multiple drafts and feedback of infographics produced, interviews with students and facilitators, and final infographic products. While this data collected in the 2012-2014 period provides the primary sources for the research and findings, we situate this information in consideration of the ongoing work currently (2015-2016) being continued by the research and development team, as much of the present trajectory is informed by the findings of the earlier period.

Results

While reports of prior and future cycles are presented elsewhere (Polman et al, 2014*)* this report highlights the salient findings of a program designed specifically as an informal educational space for out of school student interns.

At the start of this research, the extent with which the infographic internship had definitive stages was unclear, nor had the internship facilitators determined a specific sequence of stages in advance. Only after reviewing the evolving curriculum, student generated work, and facilitator objectives did our team recognize that certain emergent themes and design iterations of the science data journalism curriculum occurred in a chronologically distinct pattern. Cycle 1 occurred March 2013-July 2013. The instructional components of this cycle focused on infographic familiarity, literacy, and deconstruction. The ten participating interns were treated as employees of the university and were under contract to be paid for their work only after the successful editorial review and publication of an infographic. Instruction came in the form of explicit lessons, graphic design workshops, and 1:1 student coaching. Students were invited to pick any science infographic topic that was of personal relevance to them. As such, the student interns were personally invested in their projects, yet the research topics frequently lacked existing valid scientific research, accessible quantitative data, or trustworthy sources. See Figure 1 for an example.

<u>Figure 1</u>. This infographic illustrates the theme of personal relevance in Cycle 1.
The author of this infographic was considering using hair relaxer.

In response to the success of incorporating personally relevant topics and the challenges regarding finding data witnessed in Cycle 1, Cycle 2 (July 2013-January 2014) thematically focused on appropriate topic selection, utilizing data, and contextualizing scientific information. Most interns returned for Cycle 2 and four new interns joined the project. In Cycle 2, an emphasis on data collection and analysis was paramount and design that had some narrative flow was encouraged. Interns could still choose a topic, though they were required to draw data specifically from scientific or academic journals. Facilitators of the project spent less time on direct instruction and focused more on appropriate framing of topics, 1:1 coaching, and project design. Peer to peer and editor feedback of infographics occurred regularly prior to publication. Near the end of Cycle 2, a curriculum design chart was developed by the facilitators to capture the overall flow of the updated infographic creation cycle (see Figure 2).

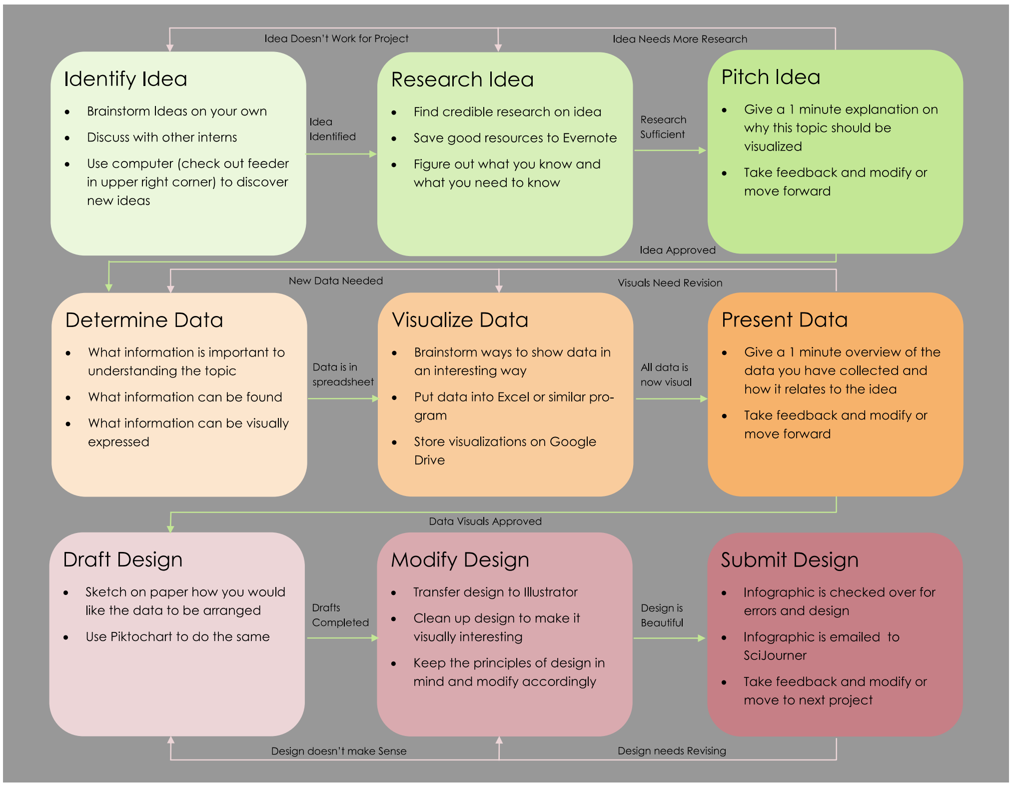

Figure 2. Infographic Curriculum Chart, Cycle 2.

Cycle 3 (January 2014-October 2014) had a more specific emphasis on quantitative information, data hygiene, scale, fair presentation of data, and telling a visual story to viewers of the infographic. In this iteration of the project, interns were still free to pick a specific topic of interest, though the topic needed to be within the broad field of 'agriculture.' The design of this cycle continued to follow the curriculum diagram outlined in Cycle 2. Facilitators placed an increased emphasis on design and presentation with outcome-oriented objectives related to publishing legitimate, usable, scientific scholarly artifacts to be made available to the public. As in the other cycles, final products would be published on an online science news magazine and infographic archive.

Near the end of this research funding cycle the project was approved for extended and ongoing support to continue the high school infographic internship. As facilitators of the field site move forward the key findings regarding infographic literacy, data mining & analysis, topic selection, appropriate feedback, intended audience, and personal and social relevance will continue to inform the future cycles of curriculum design. These lessons provided a foundation for a week-long professional development in June 2015 for other educators to implement these activities in their own classrooms and curricula. Our team continues to collaborate with a variety of teachers in formal and informal learning spaces to advance this work and consider iterative design principles to meet the needs of a diverse range of students.

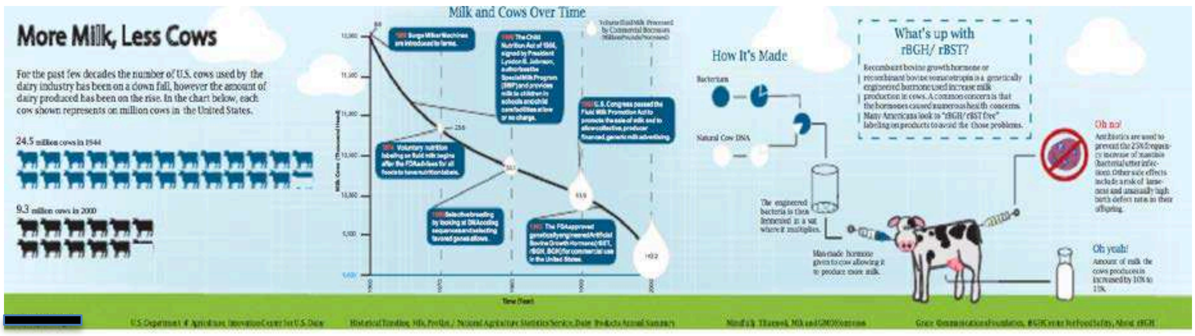

Figure 3. This infographic illustrates the storyline approach with consideration of scale.

Significance

This study offers a contribution to educational scholarship regarding science literacy, the invitation for young people to meaningfully engage with quantitative or statistical data, and the personal and social relevance of scientific topics to young people. This infographic project engages multi-modal components of STEM by exploring science topics utilizing computer software technology, through iterative design stages to illustrate scientific concepts and mathematical relations. Specifically, this research demonstrates the affordances and constraints of various scaffolding and intervention in an out of school learning environment geared at scientific literacy in young people through the design of infographics. These findings highlight specific practices and strategies to engage a diverse range of students in scientifically meaningful discourse and invite them to identify with science, at least in terms of life relevance. This report details specific strategies that work based on multiple iterations of evidence based practice and design. These strategies may be readily exported and tailored to other contexts and learning environments. Further, this work provides groundwork for a future trajectory of similar curricula with an increased focus on personal life relevance and daily engagement with science, offering multi-media outlets for student voice, accessibility and ownership of STEM data, and increased student agency through scientific competencies. Such objectives are already in focus as our team advances this work in our next stage of research and development, and has informed subsequent teacher trainings.

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Exploring African-American Middle-School Girls' Perceptions of Themselves as Game Designers

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Abstract: Computational algorithmic thinking (CAT) is the ability to design, implement, and assess the implementation of algorithms to solve a range of problems. Supporting Computational Algorithmic Thinking (SCAT) is a longitudinal project that explores the development of CAT capabilities by guiding African-American middle school girls through the iterative game design cycle, resulting in a set of complex games around broad themes. This paper explores African-American middle school girls' (called SCAT Scholars) perspectives of their SCAT experience and perceptions of themselves as game designers.

Introduction

Computational algorithmic thinking (CAT) is the ability to design, implement, and assess the implementation of algorithms to solve a range of problems. CAT makes explicit a critical aspect of computational thinking through its focus of understanding how learners identify and understand a problem, articulate an algorithm or set of algorithms in the form of a solution to the problem, and evaluate the solution based on some set of criteria. CAT focuses specifically on how the human, as computing agent, designs, implements, and assesses an algorithm (or an "abstraction of a step-by-step procedure for taking input and producing some desired output") or set of algorithms to solve a problem. CAT is focused on the algorithms designed, adapted, implemented, and discarded by the human (as computing agent) on the journey toward choosing the "right" abstractions. (Wing, 2008; Thomas, 2008). CAT is an important scaffolded on-ramp as students develop more advanced CT capabilities and apply CT to solve problems that are more constrained and require greater and greater expertise. CAT lies at the heart of Computer Science, which is defined as "the study of algorithms" (Schneider & Gersting, 2010). CAT embodies the ability to think critically and creatively to solve problems and has applicability in a range of areas from Computer Science to cooking to music (ITSTE-NETS, 2007; Polya, 1973; Wing, 2006; Wing, 2010).

SCAT is a longitudinal between-subjects research project exploring how African-American middle-school girls develop CAT capabilities over time in the context of game design (Thomas, 2014). SCAT is also a free enrichment program designed to expose middle-school girls to game design. The goals are: 1) to explore the development of CAT capabilities over three years in African-American middle-school girls as they engage in iterative game design, and 2) to increase the awareness of participants to the broad applicability of CAT across a number of industries and career paths. Spanning three years, participants, called SCAT Scholars, develop CAT capabilities as they engage in the game design cycle to design more and more complex games. SCAT Scholars begin the program the summer prior to their 6^{th} grade year and continue through their 8^{th} grade year. They engage in 3 types of activities each year (called a SCAT Season): 1) a two-week intensive game design summer experience; 2) twelve technical workshops where Scholars implement the games they have designed using visual and programming languages (e.g., SCRATCH, App Inventor) in preparation for submission to national game design competitions (e.g., National STEM Video Game Challenge, Verizon Innovation App Challenge); and 3) field trips where Scholars learn about applications of CAT in different industries and careers. This paper aims to explore the following research question: *How does participating in SCAT impact Scholars' perceptions of themselves as game designers?* We begin to address our research question by examining the individual end-of-season questionnaires collected over the course of two years (or Seasons) of the SCAT project.

Background

The iterative game design lifecycle involves several phases, which are also iterative (Fullerton, et. al, 2004). During brainstorming, Scholars generate many ideas for games and present those ideas. Once an idea is selected, paper-and-pencil drawings are created, called storyboards, that include demo artwork. Playtesting is next, which involves bringing actual players from the target user group in and observing them as they play the game in real time, getting feedback about the game experience to inform the design of the game (Fullerton, et. al., 2004; DiSalvo, et al., 2009). Next, Scholars create a playable physical prototype using paper-and-pencil and/or craft materials. Then, a rough software prototype is created which models some aspect(s) of core gameplay followed by more playtesting. Next comes creating the design document, which outlines every aspect of the game and how it will function followed by implementing the game with playtesting throughout implementation. Finally, quality assurance testing is done with continued playtesting. At any point in the game design cycle, revisiting previous phases may be required.

SCAT learning environment

The facilitator plays a major role in the development of Scholars' CAT capabilities in the SCAT learning environment as she serves first as the primary modeler and then as a just-in-time coach (Collins, Brown & Newman, 1989). In addition, the facilitator leads and supports discussions that help Scholars as they think through their designs, helps them make connections across dyad experiences and problems as they design and implement their games, and models the kinds of questions Scholars should be asking themselves and their peers as they develop algorithms for their game designs, move through the iterative game design cycle, and reflect on their use of CAT (Koschmann, Kelson, Feltovich & Barrows, 1996). As Scholars work in small groups of two on their game designs, she walks from group to group asking them questions about their designs, helping them identify problems and issues, illustrating for them how to use the Design Notebook and other tools and resources provided to them to help them design their games, and serving as a sounding board for dyads as they design.

Although the facilitator is a critical component to the SCAT learning environment, she cannot be with every group or individual all the time. To help overcome that limitation and to help Scholars develop more expert CAT capabilities, the Design Notebook has been created to coach Scholars as they engage in CAT through game design. The Design Notebook has been integrated into SCAT activities, affording Scholars multiple opportunities to develop CAT capabilities while working individually and collaboratively in small groups. The Design Notebook contains paper-and-pencil based tools that coach groups and individuals in the ways cognitive apprenticeship suggests (Collins, Brown & Newman 1989; Puntembekar & Kolodner, 1998) by using a system of scaffolds (Owensby, 2006; Thomas, 2008). Each scaffold in the system supports groups and individuals in a particular way and addresses a particular difficulty that learners may face when engaging in complex cognitive skills, processes, and capabilities like designing an experiment, interpreting and applying the experiences of experts, or engaging in CAT (Owensby, 2006; Thomas, 2008). Given that Scholars will be able to move through the iterative game design cycle at their own pace, those Scholars or small groups who are further along in the game design cycle scaffold dyads who are not as far along (Vygotsky, 1978; Roschelle, 1996; Owensby, 2006; Thomas, 2008; Palincsar & Brown, 1984). In addition, different Scholars bring different perspectives to the dyad, which contributes to greater understanding by the small group as they work.

Methods

Setting and participants

This research takes place at a small women's liberal arts college in the Southeastern United States. Each Season (which runs from June or July through the following May), Scholars participate in the three activities described earlier: a two-week summer experience, workshops, and field trips. This paper focuses on data collected across the first two SCAT seasons, which ran from July 2013 – May 2014 and June 2014 – May 2015, respectively. Over these two years, we have worked with a total of twenty-three (23) African-American girls from their 6th grade year (Season 1) through their 7th grade year. Each year, we work with twenty (20) Scholars. We had three new Scholars from Season 1 to Season 2, representing a retention rate of eighty-five percent (85%). Of these 23 SCAT Scholars, ninety-six percent (96%) had never used SCRATCH, and none of the Scholars had ever engaged in the game design cycle in this way to design novel games for social change.

Data collection and analysis

We collected end-of-season questionnaire data at the end of Season 1 as well as Season 2 to explore our research question. The end-of-season questionnaire was designed to provide insights into Scholars' perspectives and feelings about their SCAT experience, their understanding of CAT, their perceptions of themselves as game designers, and the application of concepts or ideas learned in SCAT to other areas of their lives outside of SCAT. We performed content analysis on the questionnaire responses, identifying themes related to Scholars' thoughts about the kinds of algorithms they designed during SCAT, what they liked and disliked about game design, their perceptions of themselves as game designers, and their feelings about their SCAT experience. Three raters analyzed the questionnaire responses independently, identifying themes that emerged from the responses. Then, all of the themes identified independently were discussed and an agreed upon set of themes emerged from the discussion. Then, the same three raters analyzed the responses again using the agreed upon set of themes. Inter-rater reliability was 87%.

