SciNews Online: Scaffolding the Construction of Scientific Explanations

Sebastian de la Chica
Institute of Cognitive Science
Department of Computer Science
University of Colorado at Boulder
UCB 430
Boulder, CO 80309-0430 USA
sebastian.delachica@colorado.edu

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Abstract
Middle and high-school science teachers have traditionally introduced current events in the classroom to leverage news topics relevant to the curriculum, such as the Sumatra Tsunami or Hurricane Katrina. SciNews Online is an online research environment co-designed with science teachers for learners to construct web reports on the science behind the news on natural disasters. Writing scientific explanations provides valuable learning opportunities for learners to engage in a realistic and educationally relevant science task. Here I highlight the design of the Scientific Explanation Activity, a scaffolded environment that supports learners' construction of scientific explanations using multiple online sources. The Scientific Explanation Activity focuses on supporting the development of key information literacy skills for sense-making in science inquiry, namely information integration across sources and effective scientific argumentation.

Keywords
Scaffolding, online research, educational technology design, digital library, concept map.

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces—graphical user interfaces; K.3.1. [Computers and Education]: Computer Uses in Education—computer-assisted instruction.

Introduction

Writing scientific explanations requires learners to integrate scientific concepts with their prior knowledge and with evidence gathered from different information sources, and to communicate effectively using established rules of discourse in the science domain. As a result, learning to use the cognitive strategies necessary to formulate scientific explanations emerges as a promising component of science education. However, learners often struggle proposing explanations based on evidence and logic instead relying mostly on their prior beliefs and misconceptions [7]. Hence, the National Science Education Standards (NSES) emphasize the importance of developing information literacy skills to support learners

- making connections and integrating their existing scientific knowledge with different types of knowledge from a variety of sources, and
- writing scientific explanations that are logically sound and based on available evidence and scientific knowledge.

Educational digital libraries, such as the Digital Library for Earth System Education (DLESE.org) and the National Science Digital Library (NSDL.org), have emerged as a response to the pedagogical issues raised by the proliferation of online information sources purportedly providing science education materials. As learners tackle increasingly complex scientific processes and phenomena, they need to read, analyze, communicate, and learn about science concepts gleaned from multiple information sources, including a variety of online educational resources. This situation demands that learners master the appropriate information literacy skills to meaningfully engage in sense-making activities involving multiple sources of information.

SciNews Online

My prior efforts in supporting the development of information literacy skills for online science inquiry have been reflected in the design of SciNews Online (SNO), a collaborative research environment for learners to construct web reports on the science behind the news on natural disasters [3].

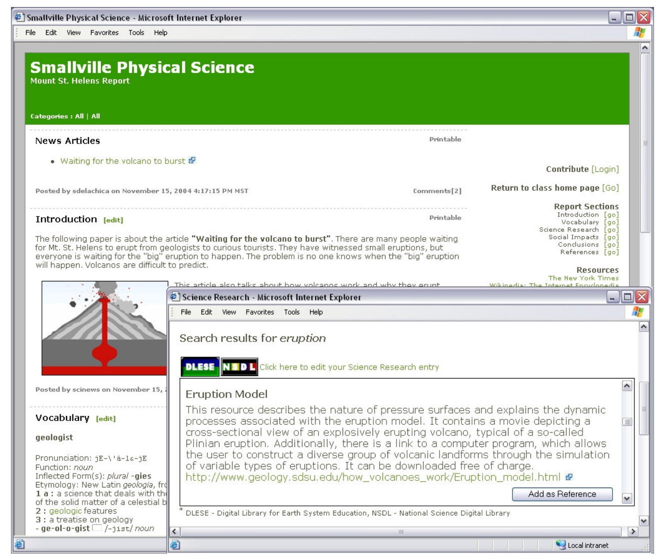

figure 1. SciNews Online: Mt. St. Helens web report

Figure 1 shows a sample SNO report built around Mt. St. Helens' heightened volcanic activity in 2004. SNO provides access to educational digital libraries such as DLESE and NSDL, as well as to the open Internet. Using SNO, learners complete different sections of their web report using a variety of activities, such as a vocabulary builder, a digital library search interface, a rich text editor, and a reference management environment. Initial usability evaluation with teachers has provided encouraging signs that the design principles explored in SNO effectively address the goals of teachers using science news in the classroom [3]. Although SNO supports a wide variety of activities to assist learners in completing their web report, this paper focuses on the Scientific Explanation Activity (SEA) designed to scaffold learners during the construction of scientific explanations for natural disasters using multiple online sources.

Design process

The educational scaffold design process is based on the principles of the science inquiry scaffolding design framework [9]. First, I identify key cognitive strategies for writing effective scientific explanations. Second, I identify and capture the challenges learners may face in deploying such strategies. Finally, I focus my scaffold design efforts on ways to assist learners in surmounting such difficulties in the context of SNO.

Cognitive strategies

Through an inductive review of prior research work in the areas of scientific argumentation for educational purposes, writing to learn, and reading and learning from multiple sources, I have identified two key cognitive strategies associated with effective scientific explanation writing:

1. Integrating information across information sources
2. Recognizing and utilizing the components of the ideal argument structure

INFORMATION INTEGRATION

Learners should adopt an integrating approach to reading and writing. Making connections among diverse science information sources enables the construction of a richer mental representation and a more complete assessment and validation of the available evidence. Key cognitive processes associated with such information integration activities include constructing an integrated account of the scientific phenomenon [4], building flexible situation models [6], and making connections across information sources [5].

SCIENTIFIC ARGUMENTATION

Learners should recognize the components of an ideal argument, including evidence, qualified claims, exceptions, warrants, and backings [10], as they read scientific information from multiple sources. Learners should also recognize the importance of exercising all the components of an ideal argument in the construction and writing of a scientific explanation. Key cognitive processes associated with effective scientific argumentation activities include understanding and exercising the rhetorical components of scientific arguments in a manner consistent with contemporary science practice [10], and recognizing the characteristic components of scientific discourse [4].

Learning challenges

I use a scenario-based design approach to capture envisioned learning situations using rich textual descriptions. To identify the challenges learners may face, I have specialized the claims analysis process [1] for use in the design of educational technologies. This adapted claims analysis process uses the targeted cognitive strategies and processes to drive the critique of the evolving design from a pedagogical perspective.

This approach maintains the focus of the design process on the targeted cognitive strategies and processes and provides a permanent record of the design goals and expectations.

Scaffold design

As seen in figure 2, the Scientific Explanation Activity (SEA) design includes three main components: the References component, the main Work Area component, and the Notebook component

The References component provides ready access to the educational web resources selected as references. This component displays the title and URL of each reference, plus a short description of its contents if available from the referring digital library. Learners may access any one of the references by clicking on the URL link. The References component allows learners to switch across resources easily, thus facilitating connection-making across information sources.

The Work Area consists of three tabs (Explore, Read and Write) to structure and support the exploration and reading of the references and to assist learners in writing the scientific explanation. The Explore tab uses a concept map visualization [8] to display an educational summary of the references for concept-based exploration and navigation of the information space. The contents of the concept map summary are generated from the references using multi-document summarization techniques adapted for educational content collections [2]. The visualization uses font size to represent how many references discuss each concept in a manner similar to *tag cloud* visualizations found in social tagging sites such as del.icio.us. Clicking on a node displays a popup window with the list of references that discuss that particular concept. Learners may access any one of the relevant resources by clicking on the displayed URLs on the popup window. The Read tab displays any resource of interest after clicking on a resource URL. The Write tab provides a What-You-See-Is-What-You-Get (WYSIWYG) rich text editor where learners write the scientific explanation. The Explore tab's concept map visualization and the Read tab's resource access promote information integration as they support both the content-based navigation of the information space and the comparison of how different references discuss particular concepts. Such capabilities may prove particularly useful to encourage learners to compare and contrast available evidence about the phenomenon being investigated and to evaluate potentially competing scientific claims.

The Notebook component supports note-taking by exposing the four key dimensions of the ideal scientific argument structure, namely evidence, warrants, backings, and conclusion. Each note-taking section uses a feedback icon and a guiding question to encourage learners to take notes during the exploration, reading, or writing activities, thus promoting information integration across resources. The feedback icon appears as an exclamation mark if there are no notes for the given section or as a check mark otherwise. The guiding questions promote effective scientific argumentation by exposing key components of the ideal argument structure both during reading and writing. The Notebook component facilitates information integration serving as a "boundary object" across reading and writing activities.

The Explore tab provides a concept map visualization of the educational summary of the references. Nodes represent key educational concepts contained in the references and links represent pedagogically relevant relationships between those concepts. The size of the font used to display each concept represents how many resources discuss the concept. Clicking on a concept allows navigation to the resources discussing that concept.

The References component allows ready access to the resources. Clicking on the URL opens the educational resource in the Read tab.

The Work Area component structures the task of writing a scientific explanation to align with the cognitive processes involved. Learners can explore the information space, read resources in detail and write a scientific explanation, switching across tasks as necessary.

The Notebook component is always visible enabling ongoing information integration through guided note-taking. The Notebook serves as “boundary object” between reading and writing activities.

Guiding questions make the constituents of an ideal scientific explanation explicit to the learner, thus guiding note-taking activities to address these dimensions. The feedback icons also encourage note-taking.

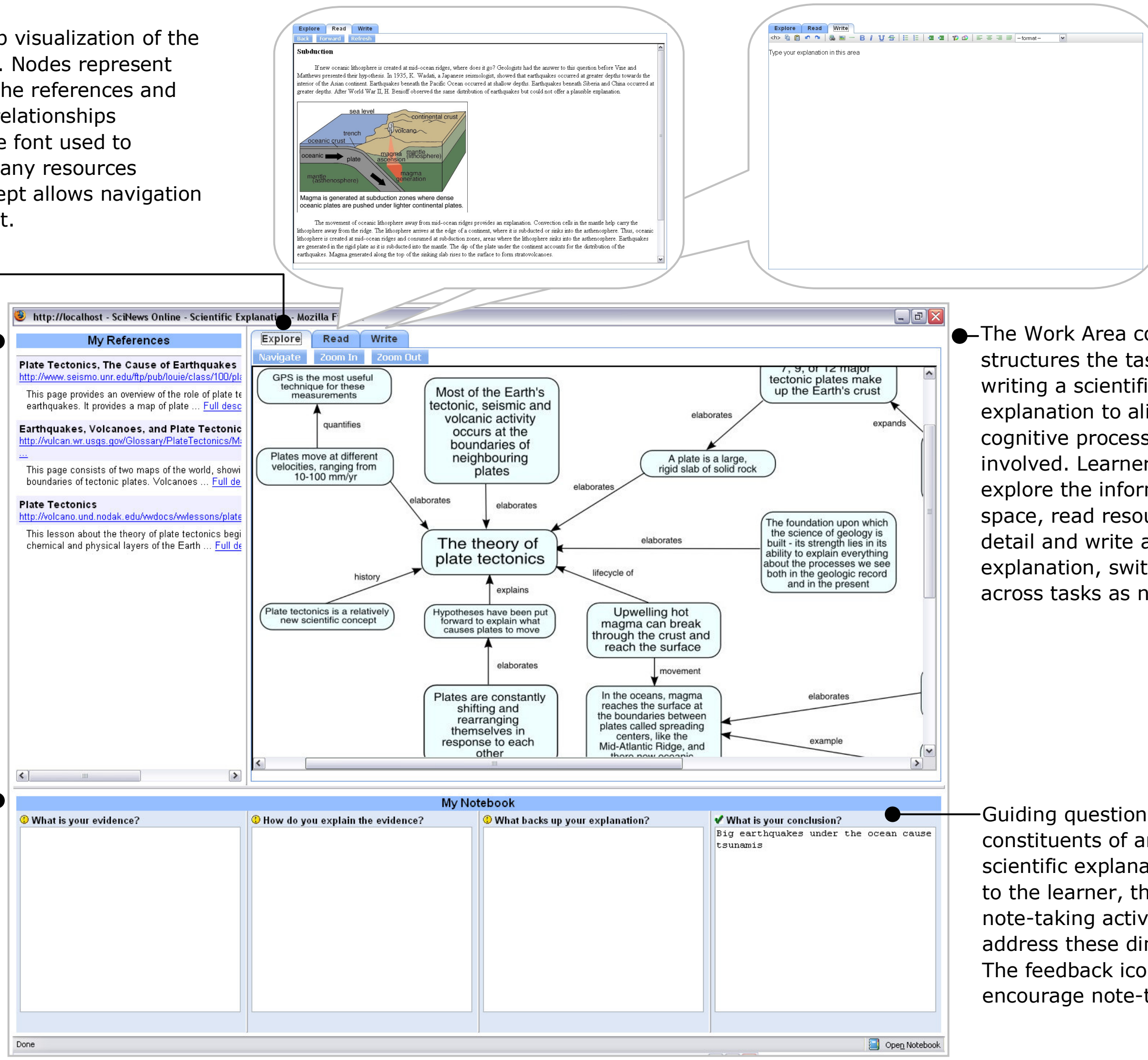

figure 2. Scientific explanation activity: Sumatra Tsunami (earthquakes and plate tectonics)

HCI implications and future work

The design of educational technologies should target specific learning outcomes in realistic educational situations. In my work, I integrate educational scenario-based design with a modified claims analysis technique to target the development of specific cognitive strategies. I am combining a usability evaluation with first year university students with a study to assess the learning impacts of SEA. This learning study evaluates the quality of the generated scientific explanations and the cognitive strategies employed by students using SEA. Since I have tracked the pedagogical intent of the different features of the design using claims analysis, I will be able to perform a detailed assessment of the effectiveness of the design.

Making sense of complex scientific phenomena requires appropriate conceptual knowledge and sophisticated information literacy skills. It is my hope that educational technologies designed to target the development of specific cognitive strategies, such as SciNews Online, may help learners begin to meet the challenges of online science inquiry in the 21st century.

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