Data informed learning: A next phase data literacy framework for higher education

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ABSTRACT
Accessing, using and managing data is increasingly recognized as an important learning outcome in higher education. Approaches to data literacy have typically been informed by information literacy. New approaches to information literacy have emerged that address how information is used in the different disciplinary contexts in which people learn and work. Successful approaches to data literacy will also need to address contextual concerns. Informed learning is an approach to information literacy that purposefully addresses contextual concerns by suggesting pedagogic strategies for enabling students to use information in ways that support discipline-focused learning outcomes. As part of an ongoing investigation, we advance data informed learning as a framework for data literacy in higher education that emphasizes how data are used to learn and communicate within disciplinary learning contexts. Drawing from informed learning, we outline principles and characteristics of data informed learning, and suggest future directions to investigate ways that data are used in real-world environments.

Keywords
Data literacy, data informed learning, information literacy, informed learning, higher education

INTRODUCTION
In their 2012 white paper, Tenopir, Birch, and Allard identified data curation as a top trend in academic libraries. Building on this white paper, the Data Information Literacy Project (DIL) recognized that support for data management education "provides an opportunity for libraries to gain entry into the research life of students and faculty (DIL Guide). Data literacy, defined by Wikipedia (2015) as “the ability to read, create, and communicate data as information,” is becoming a focus in higher education curricula (Prado & Marzal, 2013). Researchers have drawn from the ACRL (2000) Information Literacy Competency Standards for Higher Education to develop sets of data competencies (e.g., Carlson, Fosmire, Miller, & Nelson, 2011; Prado & Marzal, 2013). However, challenges have been made concerning the efficacy of generic approaches to information literacy, such as the standards, for enabling people to use information in the various contexts in which they live and work (e.g., Bruce, 1997; Lloyd, 2010).

Modeled after skills-based information literacy, current constructions of data literacy are subject to the same concerns. Informed learning is an alternative approach to information literacy that closely associates using information with learning and working in disciplinary situations (Bruce, 2008). The potential of the informed learning approach has already been recognized for its applicability to the further development of data literacy (Carlson, 2015). In the following sections, we advance data informed learning as a new framework for data literacy for use in higher education.

METHODS
The aim of this project was to develop a data literacy framework for higher education that places learning about using data in the context of disciplinary learning. Our approach was modelled on prior research using the ACRL (2000) information literacy standards to frame data literacy (Carlson et al., 2011; Prado & Marzal, 2013). However, instead of using the standards, we investigated and selected an information literacy approach that emphasizes using information within disciplinary contexts. This information literacy approach was adapted to develop a data literacy framework that places learning about using data in the context of disciplinary learning. Three steps were involved in the process:

1. Analyzing existing data literacy frameworks and curricula to identify key aspects.
2. Identifying the key aspects of frameworks in which information literacy is viewed as an element within disciplinary learning contexts.
3. Adapting a select information literacy model to develop a new data literacy framework capable of
enabling students in higher education to engage with data within disciplinary learning contexts.

DATA LITERACY MODELS
The emerging construct of data literacy has typically been closely related to information literacy (e.g., Prado & Marzal, 2013; Shield, 2004), and it is reasonable to assume that the development of data literacy may be informed by the scholarly discussion that has surrounded information literacy. For example, information literacy models have been categorized as: 1) generic information skills, 2) using information within disciplinary settings, or 3) using information critically to transform oneself or the world (Lupton & Bruce, 2010). Evolving definitions of data literacy have primarily been drawn from course curricula or other educational programming (e.g., Carlson & Bracke, 2015; Kafel, Creamer, & Martin, 2014; Qin & D’Ignazio, 2010; Stephenson & Caravello, 2007; Wong & O’Connor, 2010). Building on this work, researchers have used the ACRL’s (2000) information literacy standards and initial research findings to suggest lists of competencies for data literacy (Carlson et al., 2011; Prado & Marzal, 2013). Described in Table 1, the various models are comprised of skills related to accessing, managing, communicating, preserving and ethically using data for both undergraduate and graduate education. Placing less emphasis on conducting original research, models focused on the undergraduate level also emphasize having a general awareness of data and engaging with existing data in various ways. Drawing from Lupton and Bruce’s (2010) information literacy framework, these delineations of data skills can be seen as aligned with a generic approach to data literacy.

INFORMATION LITERACY IN CONTEXT
Responding to the need to move beyond skills-centric standards, the recently released Framework for Information Literacy for Higher Education (ACRL, 2015) emphasizes contextual aspects of information literacy by discussing the implications of information being developed and understood within communities. This point has also been made by a number of researchers, who have suggested that learning generic information skills does not prepare people to use information in real-life contexts (e.g., Bruce, 2008; Lloyd, 2010). New frameworks have been developed that reframe information literacy within disciplinary contexts. One such framework portrays information literacy as a type of practice (Lloyd, 2009), which is best learned through participation in a community of practitioners (Lloyd, 2010). An alternative framework describes information literacy as a part of learning about a disciplinary subject (Bruce, 2008). With its focus on learning, the latter framework is applicable for use in higher education settings. This framework is referred to as informed learning.

<table>
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<th><strong>Description</strong></th>
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<tr>
<td><strong>Awareness</strong></td>
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<td>Understand what data are and its role in communities or society</td>
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<td><strong>Access</strong></td>
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<td>Understand how to identify, locate, and use appropriate datasets and databases</td>
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<td><strong>Engage</strong></td>
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<tr>
<td>Evaluate, analyze, organize, and interpret existing data; make decisions based on data</td>
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<td><strong>Manage</strong></td>
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<td>Plan for and manage data, including organizing and analyzing, developing protocols for security and storage, sharing, and documentation</td>
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<td><strong>Communicate</strong></td>
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<td>Synthesize, visualize, and represent data</td>
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<td><strong>Ethical use</strong></td>
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<td>Acknowledge data sources, evaluate and manage risks, understand issues related to data reuse</td>
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<td><strong>Preserve</strong></td>
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<td>Be aware of curation practices for long-term storage and use</td>
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Table 1: Elements of generic data literacy models

Informed Learning
Informed learning emphasizes “learning” as an outcome of engaging with information. Based on nearly two decades of research into personal, educational and professional experiences of information literacy, informed learning was introduced in a monograph by the same name (Bruce, 2008) and has been elaborated on in a number of journal articles (Bruce & Hughes, 2010; Bruce, Hughes, & Somerville, 2012; Bruce, Somerville, Stoodley, & Partridge, 2013; Hughes & Bruce, 2012). Three principles govern informed learning (Bruce, 2008). First, new ways of using information must build on students’ prior experiences. Second, learning to use information should occur at the same time as learning about a disciplinary subject. Last, informed learning should result in students becoming aware of new ways of using information as well as developing new understandings of the subject being studied.

A number of characteristics are associated with informed learning, which reinforces the idea of information use being determined by the disciplinary context (Hughes & Bruce, 2012). The information practices addressed through informed learning are drawn from academic, disciplinary or professional practices relevant to what is being studied. The types of information are drawn from
the disciplines as well, and are not limited to the textual information typically used in higher education. For example, in a music course sounds may be considered information (Lupton, 2008), while in nursing course embodied information may be relevant for understanding patient care (see Bonner & Lloyd, 2011 study of nurses). Another characteristic suggests that informed learning involves the overlap of several areas of expertise, including discipline experts, technologists and librarians, and therefore suggests that all of these parties must come together to develop informed learning education. Informed learning is also likely to be active, drawing in pedagogic strategies such as problem-based learning or inquiry-guided learning that tend to involve using information to learn about a disciplinary subject.

**DATA INFORMED LEARNING**

Drawing from informed learning (Bruce, 2008), we introduce *data informed learning* as an approach to data literacy that shifts the focus from acquiring generic data-related skills to students learning how to use data in disciplinary contexts. Table 2 outlines the principles of data informed learning, which emphasize building on students prior experiences of using data, and explicitly focusing on learning to use data while learning disciplinary content. Examples are provided to suggest how data informed learning may be used to guide instructional design decision-making. Three key aspects of informed learning are beneficial for developing a data literacy framework supportive of learning to use data in disciplinary learning contexts. Data informed learning:

- guides data-related course content (type of data and data usage are determined based on how they support subject-focused learning outcomes for the course);
- encourages coursework relevancy (outcomes related to data use are determined by learning context); and
- supports lifelong learning (using data in the context of learning and doing prepares learners to use data to learn in professional and personal settings).

The characteristics of informed learning (Hughes & Bruce, 2012) suggest ways to enable students in higher education to use data that focus on learning within their discipline. Data informed learning would encompass the various ways that data are used in academic, disciplinary or professional contexts, which would include research, but would also be inclusive of working with existing data to make data driven decisions, and so forth. Just as information in the informed learning model is defined as anything that is informing, data would be anything that people might construe as data, such as experimental data, but also election results or a weather forecast. Active learning pedagogies that require students to access, engage, manage, communicate or preserve data would foster appropriate opportunities for learning about data and disciplinary content. Developing coursework for data informed learning would require collaborative efforts, particularly between discipline experts and librarians who understand different ways that data are used.

**FUTURE DIRECTIONS**

The development of data literacy may be informed by the half-century of scholarship aimed at framing information literacy to support learning in higher education. Data informed learning is an approach to data literacy designed to address shortcomings associated with generic skill-based models by having students learn to use data within the context of disciplinary learning. As with informed learning (Bruce et al., 2013), the evolving construct of data informed learning needs to be further refined through research. Such research would investigate the various ways that data are used in real-world environments, such as business, social media, research labs, class projects, and so forth, to inform the design of learning environments where learners use data in ways that support disciplinary learning outcomes.

**REFERENCES**


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<th>Principles</th>
<th>Course example</th>
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<td>1. New ways of using data must build on students’ prior experiences</td>
<td>In an accounting course, the instructor may have students reflect on their own experiences of balancing a checkbook and then relate that to a journal ledger or a general ledger.</td>
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<td>2. Learning to use data should occur at the same time as learning about a disciplinary subject</td>
<td>A nuclear engineering course might apply the concepts of authority, quality, and accuracy to the use of data repositories by looking up evaluated nuclear reaction data in two different databases, and compare the results (Zilinski, Sapp Nelson, &amp; Epps, 2014).</td>
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<td>3. Learning should result in students becoming aware of new ways of using data as well as developing new understandings of the subject being studied</td>
<td>A computer programming course may have students swap documented computer code with another team, and rerun a script to see if they can replicate the process, having them learn about using and managing data in the context of programming.</td>
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Table 2: Principles of data informed learning


