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putting the pieces together: theory and practice

Train the Teacher: Practical guidance for effective, critical teaching approaches for science and data librarians

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Abstract

This article describes an approach to guiding science and data librarians in their development as teachers, and it outlines practical skills that are important for effective teaching in the context of science information and data literacies. The authors designed and delivered two workshops for science and data librarians. In each workshop, participants explored foundational learning theories and practical tools for teaching more effectively, including lesson planning, writing learning outcomes, designing classroom activities, assessing learning, managing the classroom, and reflecting on teaching. The workshop has evolved to introduce critical pedagogical approaches as well. Based on the content of these workshops, participant feedback, and the authors' experiences, we detail practical, on-the-ground strategies for designing and facilitating effective information and data literacy instruction for STEM audiences. As partners in science education, librarians need practical educational opportunities to hone their teaching skills and develop a teacher identity.

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Introduction

Science and data librarians are important partners in STEM education. Librarians with science or data specialties are often asked to teach as part of their campus' curricula or in the form of workshops, and this role may be an important way that librarians reach their users, (Julien, Gross, and Latham 2018; Valenti and Lund 2021; Walter 2006). They help students develop science, data, and information literacy skills that can build competence in communication, evaluation, analysis, and critical thinking as future practitioners and researchers.

Position descriptions for science and data librarians emphasize many skills and competencies needed to support the research lifecycle, including expertise in research data, scholarly communications, and systematic literature searching (Ferguson 2016; Herubel 1991; Meier 2010). Teaching responsibilities are also a common part of most science and data librarian positions; however, teaching skills may be overlooked amid competing priorities for qualifications in these specialized positions. (Brecher and Klipfel 2014; Chen and Zhang 2017; Ferguson 2016).

While building skills in teaching and instruction is important for many librarians, scholars have pointed to a disconnect between the teaching responsibilities commonly included in librarian positions and the lack of educational and professional development opportunities available to build expertise (Brecher and Klipfel 2014; Walter 2006). Science and data librarians may have limited formal training in the classroom, and librarians may be left to develop foundational understandings of adult learning and critical theory, as well as practical skills in instructional design and classroom management, on their own. This article explores the competencies needed to be an effective teacher-librarian in the science classroom and shares effective and creative approaches to developing information and data literacies in STEM learners.

Background on the workshops

In 2017, we delivered a day-long workshop through the New England Regional Medical Library (NNLM NER) to help science and health science librarians develop their teaching skills. The workshop was an opportunity to discuss teaching strategies and to learn how to plan an effective and engaging library instruction session. Participants discussed their identities as teachers, designed a lesson plan with learning outcomes, explored active learning strategies, and investigated classroom management and assessment strategies. The audience was academic librarians, most of whom were science, data, or health science librarians. In 2021, we were invited to repurpose the workshop for the IMLS-funded National Forum on Data Visualization in Libraries, which included participants from both academic and public libraries.

For both workshops, we designed interactive discussions and activities to engage participants in building a real lesson plan. Through this approach, we were leading by example; by showing participants the value of active learning. Both workshops are described in more detail through the links below:

- Teach Me to Fish: From Instructors to Teachers as Science and Health Science Librarians
- Beyond the Tools: Pedagogy for Critical Data Visualization Instruction

As educators and academic librarians, we were each able to bring unique and complementary teaching experiences as facilitators of these workshops. In addition to her recent master's degree in education, the first author has a 15-year career as a teaching librarian supporting STEM disciplines. Many of the example active-learning approaches and lesson designs presented in our workshops were borrowed from her work in the classroom as a science librarian. The second author holds both a bachelor's and master's degree in education, along with her master's in library science, and has previous experience in teaching in early education and elementary education classrooms. She has refined her practice during her eight-year career as an education librarian, designing in-person and online instruction for both undergraduate and graduate programs.

Building blocks of effective teaching for sciences and data librarians

Building from the outcomes of these two workshops, we recommend that librarians who teach develop a teaching philosophy, write lesson plans and learning outcomes, design learning activities and assessments, and build their reflective teaching practice.

Developing a teaching philosophy

A key component of becoming a better teaching librarian is defining your teaching philosophy, though many professional development opportunities overlook the element . Writing a teaching philosophy is an exercise in reflecting on what is important to you as a teacher and defining the learning environment that you would like to create. In *Reflective Teaching, Effective Learning* (2011), Char Booth recommends reflecting on your past educational experiences, recalling "instructors you remember," "instructors you have tried to forget," and "memorable informal learning" (2011, 5-6). These reflections can then be applied to the self, (what do you want to replicate in your classroom, and what would you prefer to avoid?) and turned into a teaching philosophy. Here's an example from *Reflective Teaching, Effective Learning*:

> I believe that teaching is really about discovery and learning: one of the greatest joys of teaching is the unique story of learning that unfolds for me and my students as we explore and experiment together side by side. I try to cultivate a participatory climate that values risk taking and learning experience that are organic. It is in the messiness and stickiness of learning where real meaning is constructed (2011, 7–8).

We consider these statements to be an opportunity to explore aspects of your identities, as well, which should be considered in the context of the classroom and the power dynamics they can create. For example, while authors of this paper encourage students in our classrooms to be co-creators of knowledge, we recognize that as cisgender, white women with advanced degrees working within the hierarchy of a university setting, there are power imbalances that must be actively dismantled to create an egalitarian learning space.

Understanding your own values and positionality as a teacher can help you navigate both the challenging power differentials that can come with teaching as a librarian (e.g. disconnects between what faculty expect you to teach and what you feel is most useful for the students) and any classroom management issues that may arise. As part of our teaching workshops, we developed a workbook that asked participants to draft a teaching philosophy before the workshop even began. We encouraged workshop participants to review their teaching philosophies after the workshop ended, and we recommend that all teaching librarians revisit their philosophies on a regular basis: As your confidence and skill set with teaching grows, your teaching philosophy will likely change for the better.

- When developing your own teaching philosophy, some key questions to ask yourself are:
- What is important to you in your teaching?
- Can you define your core values in the classroom?
- What kind of learning experience do you want your students to have?

Lesson planning

Lesson plans are an important tool for librarians who teach. They provide a road map for what you will do in a class session and how you will create a meaningful learning experience for students (Miller 2016; Saunders and Wong 2020). A lesson plan defines the scope of your content and learning outcomes, which can help you negotiate with a course instructor a shared understanding of what students concepts students will explore in their time with you (Bravender et al. 2015). These documents also help you plan the timing of your content and structure discussions. If you get off-track, the lesson plan can help you return to the goals of your lesson. In addition, lesson plans can document what worked well in a session, what needs to be revised, and what assessment information can be gathered. While lesson plans may require time to produce, they can save time as repurposable content in the future when they can be reused for the same course or modified for other courses.

We recommend that you create a lesson plan for every session that you teach. Your plan should outline the basic details about the class or session, materials or technical set-up required, learning outcomes, learning activities and timing, comprehension checks, and assessment plans. We also find it valuable to document connections between your learning outcomes and the ACRL Information Literacy Frames. You should also leave space to take notes after your session on what could be improved next time. There are many great lesson plan templates available, but we use this template.

Applying the framework

A task force of the ACRL Science and Technology Section is currently working to adapt the ACRL Framework for Teaching Information Literacy to the sciences, and a draft of their recommended framework is now available (ACRL/STS Information Literacy Framework Task Force 2021). The draft draws connections between the broader ACRL Framework for Information Literacy and the STEM classroom, and we

recommend reading both documents. In addition, the Visualizing the Future project members are working to map the ACRL Framework and other components of media and critical literacy into the context of teaching data literacy and visualization (Carlito and Ogdon 2021). The ACRL Framework provides a structure for librarians to identify, introduce, and engage students with information literacy threshold concepts, or ideas core to the discipline (Booth and Mathews 2012). This student-centered approach, grounded in the science of teaching and learning, aims to encourage critical thinking and concept exploration (Bravender et al. 2015). One point we like to share in our workshops is how connected the frames are to the research lifecycle and connecting your teaching to the frames is a way for you to showcase important information literacies and disciplinary perspectives. Examples of these connections are shown in Figure 1.

ACRL FRAME	CONCEPTUAL APPLICATION TO THE RESEARCH LIFECYCLE
Information creation as process	Many formats are produced in the research lifecycle, and formats provide contextual clues about the stage of research and purpose of communication
Research as inquiry	The research process is both iterative and leads to new questions within the lifecycle
Scholarship as conversation	The work of one scientist is situated within an information context of what scholarship came before and after its publication
Authority is constructed and contextual	Guidelines for source evaluation are often oversimplified or may make binary assumptions about what is a "good" or "bad" source. This frame can also shed light on whose voices are included and excluded in scientific publishing most often, which problematizes assumptions about objectivity in the scientific process
Information has value	Critiquing the message and meaning of a visualization of data can uncover the intentional design choices made by the creator

Figure 1: ACRL frames and the research lifecycle

Think about a class or workshop that you have taught in the past or one where you were a student, and consider these questions:

- Can you identify one of the frames that applies to this example?
- What skills or knowledge was explored by students?

Writing learning outcomes

Learning outcomes are the keystone for a successful teaching experience. They determine what you will teach and how you will measure whether or not students learned the key skills and concepts of your lesson

(Fox and Doherty 2012; Oakleaf 2010). By engaging in backward design (identifying what you want students to do before deciding how you will teach those skills), you will more easily avoid the trap of choosing a learning strategy or technology tool just because it is flashy and "cool." Instead, you ensure the focus remains on student learning (James 2020; Saunders and Wong 2020; Wiggins and McTighe 2005).

Some questions to ask yourself as you develop learning outcomes are:

- What are you being asked to teach?
- Who are the students? What do they need to learn by the end of your session?
- How much time will be allotted for the workshop?
- How can you infuse critical concepts into this session?

Learning outcomes should be narrow, measurable, and should start with an action verb: We rely heavily on Bloom's Taxonomy to help us name and quantify what we're asking of our students (Armstrong 2010). Using verbiage from Bloom's Taxonomy helps teaching librarians more easily decide which lessons contain foundational content (e.g. at the end of this lesson, students will be able to describe how to use Boolean operators to narrow their searches) and which should contain more advanced content (e.g. at the end of this lesson, students will be able to design a narrowly scoped search in PubMed) (Adams 2015).

Building in active learning

Active learning is a form of experiential learning that is essentially having students do something besides passively listening by asking students to apply, discuss, analyze, and evaluate the material being taught (Bonwell and Eison 1991). The evidence of the benefits of active learning is well documented in the education and library science literature (Freeman et al. 2014; Knight and Wood 2005; Ross and Furno 2011), but more practically, integrating active learning strategies into your teaching is less boring (for you and your students) and can appeal to different learning preferences and abilities. By applying and practicing concepts, students can shape their own learning and make meaningful connections to the content. Some active learning strategies that we recommend for the science classroom are represented in Figure 2.

Some other active strategies that we like are concept mapping, games (such as bingo or jeopardy), case studies in groups, or time for students to work on their own topics. In addition, you will need to plan how to deliver and facilitate your learning activities. In an in-person class, we often use worksheets or paper and markers. Other tools that can be helpful in the physical or virtual classroom for active learning include Mentimeter, Google tools (such as Docs, Slides, or Jamboards), students' phones (ask them to take a photo or make a video based on a prompt), or Padlet. As you are selecting an active learning technique, revisit your learning outcomes and consider how students might practice them.

ACTIVE LEARNING STRATEGY	EXAMPLES: ASK STUDENTS TO…
Discussion	Read or watch something and then discuss in small groups Write open-ended questions that encourage critical thinking or response
Think-pair-share	Think about their response, discuss with a partner, and then have the pairs share with the group Brainstorm data visualizations or problem-solving a difficult information need
Jigsaw	Explore a resource or tool in small groups, then present the resource or tool to the larger group

Figure 2: Active learning strategies

Critical pedagogy

Critical pedagogy is a teaching philosophy that invites educators to encourage students to critique historical, social, economic, and political power structures as part of their learning (Sengupta-Irving and Yeh 2014). The concept has evolved over the decades to include categories such as culturally-responsive, relevant, or sustaining pedagogies. Within the library science discipline, Dr. Nicole Cooke presents a framework of literacies- emotional literacy, design literacy, media literacy, racial literacy, etc.- to shape a holistic definition of critical cultural literacy (Cooke 2021). In the context of teaching in science librarianship, practicing critical pedagogy can start with small shifts, such as reframing a discussion question in a way that helps students identify power structures (Pagowsky and McElroy 2016). For example, when talking about bias in the scientific literature, one might frame bias as related to an individual researchers' implicit or explicit beliefs, which will be reflected in their scientific practice. This approach neglects the institutionalized power that has shaped that researcher, however. A systematic-level discussion of scientific bias might have students discuss issues like the limited reporting of negative results, algorithmic or indexing biases, trends in funding availability, and privileged access to scientific research.

When preparing a critically-informed lesson plan, you might:

- Use example topics (and search terms) that have a critical framing.
- Develop guided questions about the production of scholarly information related to audience, authority, and accessibility.
- Point out exclusion and power in citation practices

Assessment

Conducting assessment of instruction is complex, and especially in a one-shot or workshop setting, it can be very challenging. Assessing in the library classroom is about both improving learning and improving teaching. Meaningful assessment will take time away from class content, and as teaching librarians know, every minute of classroom time is precious. There can also be tensions between what we are being asked to assess: Student learning? Library impact? The effectiveness of our own teaching? (Farkas 2013). Assessment is a highly contextual process and to avoid getting into the weeds for our workshop (and this article!), our suggestions for effective assessment are brief. First, writing measurable learning outcomes is crucial for effective assessment of student learning (Oakleaf 2010). If you can plan for how students will demonstrate they learned a skill/concept, then you can more easily find an assessment strategy to match. Second, be mindful of student privacy concerns as you conduct your assessment: collecting student work for later review is a great way to track students' thinking in your session, but how you store that work and what you do with it later requires forethought. And lastly, we recommend getting clarity on why you're assessing as much as what you're assessing.

Some common assessment approaches include pre- and post- tests, minutes papers, observations, and rubrics. As you plan your assessment, consider these questions:

- Does the selected assessment approach match the learning outcomes?
- What questions could the selected assessment answer?
- How much time should be allotted for completion of the assessment?
- Does the assessment provide feedback on your teaching?

Classroom management

Classroom management is a very contextual challenge; every group of students is different, and the classroom experience is impacted by innumerable variables (day of the week, the time of the class, the temperature in the classroom, etc.). Especially for librarians, who often teach in different classrooms with different groups of students and instructors for each of their instruction sessions, keen classroom management skills are of great value (Blackburn and Hays 2014). However, there are a few classroom management strategies that we have identified as being useful in any teaching context. Time management is a challenge for many teaching librarians, because we often get one opportunity to offer a lesson and feel pressured to teach everything

within that short window. Thus, writing learning outcomes is key: Learning outcomes force us to prioritize what is most important to a particular group of students and keep us from getting lost in the weeds. Using a lesson plan template provides structure and helps us think about the timing of a lesson, which will help the session move more smoothly. It may feel cumbersome to think through timing in advance, and every teacher needs to be flexible as things arise in the classroom but having a clear plan for the session ensures that you have the capacity to handle those "in the moment" challenges. In our workshops, we had participants discuss some common "in the moment" challenges (an over-participatory student, a faculty member who is guiding the session in a different direction that the librarian had planned, etc.) and encouraged them to share with one another how they might handle such classroom management challenges. While there is no substitute for time and experience in the classroom for building confidence, sharing strategies with other teaching librarians can help you add more tools to your classroom management toolkit.

Reflection

We do not often make time to reflect meaningfully on our teaching. It can be challenging to find the time to sit and write about what happened during a session, because librarians are often being pulled in many different directions at once (Booth 2011). However, developing a reflective practice is critical to becoming a better teacher. Regular reflection allows instructors to not only improve their teaching practice around content and delivery but also consider the dynamics of power and privilege in their classrooms and the ways in which they can adjust their teaching accordingly (Brookfield 2017).

We encouraged workshop participants to keep a dedicated teaching journal, where they could commit to spending even five minutes after the end of a workshop jotting down what went well, what did not go well, and ideas for things they might change next time. Keeping a dedicated teaching journal allows you to track patterns in your teaching, which can help you make larger changes to your practice. Developing a reflective practice of *teach - reflect - revise - teach* again will not only ensure that your content is fresh and engaging for students, but it will also help you stay engaged and excited about your teaching.

Conclusion

Science and data librarians need practical opportunities to develop as teachers that are specific to the context of STEM education, especially when they have so many competing demands for building expertise. We believe that science and data librarians can build competence, confidence, and a teacher identity by exposure to basic theories of teaching and learning and by practicing the steps outlined in the article. Composing a teaching philosophy and developing a reflective practice can tether a library's instruction to one's core values as a professional. Creating lesson plans, right-sized learning outcomes, and student-centered, engaging learning activities make for a richer classroom experience. Our two workshops, which gave shape to the recommendations in this article, provide practical tips and a structure for improved teaching practice.

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