Resource Guide for Postdoctoral Researcher Development

NSF EPSCoR Workshop: Enhancing Postdoctoral Professional Skills to Advance Research and Workforce Development

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Introduction

This Resource Guide was born of frustration on two fronts. First, postdoctoral scholars (postdocs) often voice concerns that they haven't received training in the professional skills they need to succeed in their current and future positions. Second, trainers and mentors of postdocs have found themselves ill-equipped to provide lessons in the wide range of knowledge, skills and capabilities (KSCs) needed by postdocs, due both to a dearth of information about postdoc needs and the lack of a comprehensive curriculum. This frustration led to a 2022 National Science Foundation-sponsored workshop that brought together current and recent postdocs, individuals who had implemented successful postdoc training workshops, and experts in one or more KSCs.

Following the event, a number of participants agreed to combine their knowledge and produce this guide, which is aimed at postdoc mentors, postdoc or faculty development offices, postdoc associations and professional organizations, and others developing postdoctoral workshops or component lectures and exercises. This introduction provides background about the 2022 workshop, a summary of the Resource Guide's 13 training modules, and information on how to use the Resource Guide to facilitate learning experiences of varying length, format, and content. The modules were written in such a way as to be accessible to non-experts, including postdocs themselves.

Background

The initial idea for the postdoc workshop came from a group of university faculty and researchers associated with the National Science Foundation Established Program to Stimulate Competitive Research (NSF EPSCoR), an arm of the NSF dedicated to bolstering STEM research and education in states and territories that traditionally have received only small amounts of NSF funding. A six-person Project Steering Committee, made up of researchers from New Mexico, Hawaii, South Carolina, Idaho and Maine, secured NSF funding for the event, entitled "Enhancing Postdoctoral Professional Skills to Advance Research and Workforce Development." As an initial step in developing the workshop, the steering committee administered a nationwide survey to postdoctoral scholars and identified 16 KSCs (see box) that respondents believed would be important for their career success, but for which they had received minimal training. The KSCs were derived from a much broader set of researcher characteristics included in the Vitae Researcher Development Framework, which encompass "the knowledge, intellectual abilities, techniques and professional standards to do research, as well as the personal qualities, knowledge and skills to work with others and ensure the wider impact of research."

The workshop was held December 12-14, 2022 at Ghost Ranch, the former home of the legendary painter Georgia O'Keeffe near Santa Fe, New Mexico. The event brought together 26 experts (Figure 1.1, below) to develop training modules to serve as the basis for lectures and/or workshops for postdocs. Each expert participated in breakout groups facilitated by two lead authors to formulate draft versions of the modules following a common template.

Knowledge, Skills and Capabilities (KSCs)

1. Effective Proposal Writing and Income Generation
2. Research Project Management
3. Mentoring
4. Collaboration and Team Science
5. Work-Life Integration
6. Creativity
7. Leadership
8. Career Management
9. Diversity, Equity, and Inclusion
10. Data Management
11. Personal Effectiveness
12. Effective Teaching
13. Programming
14. Communicating Science to the Media and the Public
15. Meeting Facilitation
16. Individual Development Plans

After the individual modules were drafted, participants identified linkages among the initial 16 KSC topics (Figure 1.2). This process highlighted topics that were closely related and could potentially be merged or taught as part of a single workshop or course, as well as others that might be taught individually or in combination with other topics (see *How To Use This Guide*, below). During the editing phase, three of the KSCs were merged with others because of overlap in subject matter, resulting in the 13 modules that are included in this Resource Guide. These modules are in turn separated into broad categories of Personal Skills Development; Collaborating and Working with Others; Project Management; and Managing Research Data. The modules are summarized below.

photo by Brittney Van Der Wegff/New Mexico EPSCoR

Figure 1.1. Postdoc Workshop participants.

Each module comprises several sections. An *Introduction* describes what the module covers, and is accompanied by a box on *Learning Objectives* describing the knowledge and skills that are expected to be acquired through the learning experience. *Themes and Exercises* includes the subject matter content and associated exercises that can be administered in a workshop setting. *Additional Resources* includes both printed and online content that can be used to supplement the materials in this guide. Additional links to other resources can also be found throughout the text of this guide. The 13 modules are:

Module Set A: Personal Skills Development

1. **Career Management** focuses on broad, holistic career development and includes resources to create an Individual Development Plan (IDP) in order to set career goals and paths, find and develop mentoring relationships, identify career opportunities, and compete for positions.
2. **Personal Effectiveness and Leadership Skills** empowers participants to take stock of their individual skills, values and strengths, to develop and practice leadership skills, and to connect with others to build a support network.
3. **Work-Life Integration** defines work-life integration, and focuses on skills including setting personal boundaries, identifying barriers and aids in achieving integration, and assessing job opportunities through a work-life integration lens.
4. **Fostering Creativity** includes a definition of creativity, as well as activities designed to help develop attitudes conducive to creativity, and to impart strategies to foster creativity.

Module Set B: Collaborating and Working with Others

5. **Teaching** frames a teaching philosophy and approach, describes the Backward Design Model for designing courses to achieve learning outcomes, and discusses effective and inclusive learning

experiences.

6. **Collaboration and Team Science** summarizes the benefits of collaborative research, its benefits to researchers and their communities, the conditions necessary for successful and rewarding research collaboration, and the professional capacities one can develop and leverage as a participant.
7. **Facilitation** includes knowledge, practical skills, and techniques of facilitation, and instruction in developing one's own facilitation style and skills.
8. **Integrating Diversity, Equity, and Inclusion (DEI)** defines DEI, discusses DEI requirements and opportunities, and details how to develop a compelling DEI statement.

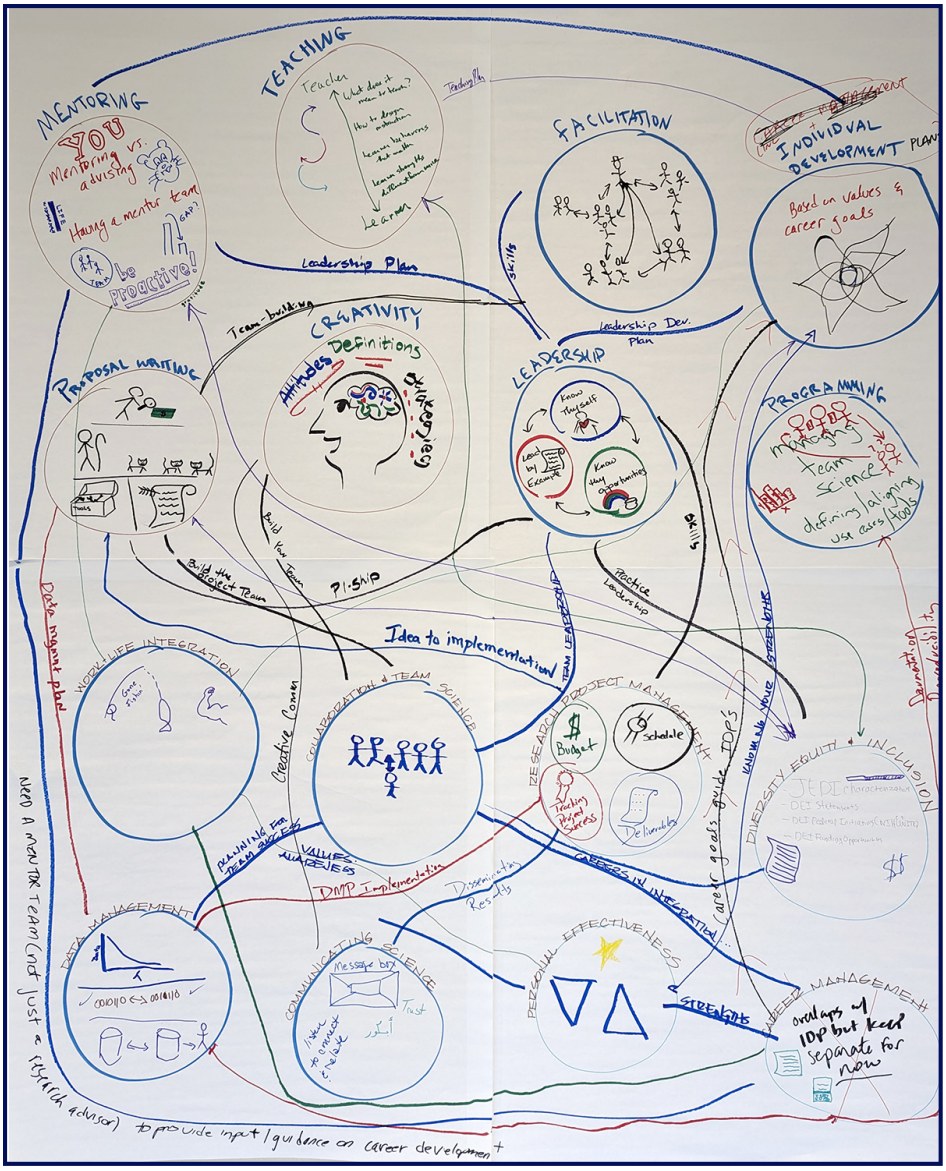

Figure 1.2. Concept map of 16 KSC's developed at the Postdoc Workshop. Over the course of the workshop, participants discussed connections between the proposed topics for postdoctoral research development. This map, co-created by team members between breakout sessions, represents the evolution of themes across interrelated topics that informed the structure of this resource guide.

Module Set C: Project Management

9. **Proposal Development** instructs participants how to develop an individual research plan, to identify potential funders and collaborators, and how to employ strategies such as logic models and a requirements matrix to craft effective proposals.
10. **Managing Research Projects** includes instruction in developing a project schedule and budget, tracking project progress, assessing and mitigating risks, evaluating project success, and identifying and communicating with key stakeholders.
11. **Communicating Science to the Public** offers training in understanding target audiences and setting realistic communication goals, crafting and delivering communications to different audiences, developing accurate and engaging stories, and preparing for media interviews.

Module Set D: Managing Research Data

12. **Data Management** defines the data management lifecycle and describes how to create, monitor and update a data management plan, and how to apply data sharing and preservation practices.
13. **Programming** imparts fundamental concepts common to many programming languages including hands-on applications with common use cases, strategies for developing reproducible research outcomes, and continuing one's programming education.

How To Use This Guide

The primary goal of this guide is to provide training modules that are easily implemented in a workshop or courses. Although the modules may have some utility for postdocs learning through independent self-study, they were designed for a group setting with active learning and group discussion. Most modules were designed so that some or all of the content and exercises can be covered in a one-to-eight hour period, though some modules such as Programming are more realistically covered over two or more days, or even a full semester.

It would be impossible to cover the 13 modules in their entirety in a single workshop or course. However, as depicted in Figure 1.2 above, there are many interdependencies among the modules and some groupings of modules are ideal for an extended workshop, a seminar series, or longer-term study by a postdoc cohort or learning community. Examples of such groupings include:

- **Enhancing Personal Effectiveness and Your Career:** 1. Career Management, 2. Personal Effectiveness and Leadership Skills, and 3. Work-Life Integration.
- **Planning, Implementing and Communicating Your Research:** 4. Fostering Creativity, 9. Proposal Development, 10. Managing Research Projects, and 11. Communicating Science to the Public.
- **Collaborating and Building Effective Teams:** 6. Collaboration and Team Science, 7. Facilitation, and 8. Integrating Diversity, Equity, and Inclusion.
- **Managing Research Data:** 12. Data Management and 13. Programming.
- **Professional Skills for the Academic Environment:** 5. Teaching, 7. Facilitation, and 8. Integrating Diversity, Equity, and Inclusion.

Any subset of modules could be mixed and matched to address local needs. For example, New Mexico NSF EPSCoR held a 3-day workshop incorporating 3. Work-Life Integration, 5. Teaching, 7. Facilitation, 9. Proposal Development, 10. Managing Research Projects, and 11. Communicating Science to the Public. At the event, individual experts taught topics 3, 5, and 7; topics 9 and 10 were taught by the same individual; and topic 11 was taught by two science writers, a radio journalist, and a television journalist.

The authors of this guide hope that you will incorporate material and exercises from a subset of the training modules. Please feel free to modify, subtract, or add content and exercises to suit your needs and the needs of your learners. We encourage you to seek feedback from your learners so that your workshops or courses continue to evolve and improve to better meet the needs of postdocs as they advance in their careers.

Module Set A: Personal Skills Development

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1 Career Management

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1 Career Management

Introduction

Postdoctoral positions encompass both the academic preparation of a student and the professional responsibilities of a faculty or research professional. It is thus not surprising that in a recent survey, postdocs rated career exploration and management among their top concerns, as determined by Heyward et al. (manuscript in prep). This module focuses on broad and holistic career development for postdocs by providing resources to set career goals and paths; to find and develop mentoring relationships; to identify career opportunities; and to successfully compete for desired positions. This section only addresses mentoring of postdocs; for information on mentoring *by* postdocs, see the Diversity, Equity and Inclusion module. In addition, this section does not provide resources to develop specific skills such as preparing CVs and negotiating salaries, which are available through career services offices at individual institutions.

Learning Objectives

1. Self-assess skills, interests and values
2. Develop a Personal Vision Statement
3. Explore career pathways that align with skills, interests and values
4. Build and monitor an Individual Development Plan (IDP)
5. Devise a mentorship plan and formulate a mentor committee
6. Explore resources for career development
7. Maximize an online presence

Themes and Exercises

Theme 1: Individual Development Plans. Individual Development Plans (IDPs) enable postdocs to identify career paths that align with their skills, interests, and values. These plans are based on personal SWOT (Strengths, Weaknesses, Opportunities, and Threats) analyses used to characterize one's professional and personal self. An excellent starting point for IDPs is the free AAAS myIDP platform, which provides resources for developing a plan, monitoring progress, revisiting goals, and making revisions; the platform also helps keep postdocs on track by sending optional goal updates via email. The University of Hawaii model is a strong example of how myIPD can be tailored to a particular institution or program.

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 1.1. Mentoring breakout session at the Postdoc Workshop.

Exercise 1. Have participants conduct a personal SWOT analysis using the Mind Tools template, and complete a AAAS myIDP Skills, Interests, and Values Assessment.

Exercise 2. Using resources such as these from Betterup and Pepperdine University, have participants develop a Personal Vision Statement that includes: interests; skills; personal values and attributes; and short- and long-term goals, including steps to reach an overall professional goal.

Exercise 3. Ask participants to explore career pathways, including further exploring career paths at myIDP based on their self-assessments; exploring non-academic careers at VersatilePhD; and conducting informational interviews to learn more about career paths, using resources such as these from HBR, Careeronestop, and the University of St. Thomas.

Exercise 4. Have participants build an Individual Development Plan at myIDP based on SMART (Specific, Measurable, Actionable, Realistic, Time-bound) objectives and regularly monitor progress. Participants should hold themselves accountable to complete IDP objectives, and to revise them as goals change.

Theme 2: Mentoring for Career Advancement. Identifying a well-suited mentor is a crucial step in career development. Characteristics to consider in choosing a mentor may include subject matter expertise, institutional affiliation, career stage, availability, personal identity, and interpersonal style. It is likely that no one mentor will be able to support all of an individual postdoc's goals, so another option is to adopt what is sometimes called a mosaic model. This entails cultivating relationships with several different mentors, including both peer-to-peer and more traditional mentors. Postdocs should consider branching out beyond their discipline, which will enable them to expand both their network and their skills.

The Four Elements of Mentorship

1. Trust building
2. Goals and shared lessons
3. Action plans
4. Celebrating successes

A mentoring relationship should be beneficial for both the mentor and the person being mentored. Developing a mentorship entails putting into practice a career development plan that lays out factors such as experiential learning opportunities and the cadence and content of meetings, and that incorporates the four elements of mentorship (box): trust building, goals and shared lessons, action plans, and celebrating successes. An overarching structure including regular meetings and activities is necessary, but continued openness to shifts in priorities and goals is also critical. Mentor and mentee should set time points for reviews of progress and collaboratively address problems and gaps in mentorship and communication.

Exercise 5. Have participants complete a table (see example to right) identifying the skills and knowledge that a mentor(s) could support in their professional development. Then have them share the table with their existing network of colleagues and ask for help in identifying potential mentors.

Exercise 6. Have participants generate a list of potential mentors based on Exercise 5. Brainstorm different methods for identifying mentors, such as societies, conferences, and introductions by colleagues, as well as communication avenues such as email, LinkedIn, and face-to-face meetings.

Goal	Mentor role
Communication Skills	Help enhance skills in writing for journal publications, or communicating to the public
Technical Knowledge	Augment data management knowledge
Discipline-specific Knowledge	Teach a specific technique or tool, or enable access to a specific piece of equipment

Table 1.1. Examples of mentor roles for Exercise 5.

Exercise 7. Encourage participants to explore a mentoring compact or contract, a foundational document that outlines expectations for the mentoring relationship. Several different models are available from the University of Wisconsin.

Theme 3: Career Advancement Tools. As postdocs advance in their careers, they will be able to pursue new interests, increase job satisfaction and salary expectations, and pursue continuous learning and professional development. Many tools are available to assist postdocs in skills needed to advance their careers such as applying for jobs; creating a professional online presence; building a professional network; negotiating effectively; and writing effective CVs and research, teaching, and diversity statements.

Exercise 8. Encourage participants to explore career resources at their home institution and online. University career development offices offer a variety of resources for postdocs embarking on a job search, including help with developing CVs, writing effective job applications, negotiation skills, and locating job sites. National organizations that provide job and career resources for postdocs include the National Postdoctoral Association and Minority Postdoc.

Exercise 9. Ask participants to develop diversity and teaching statements using resources in the Teaching and DEI modules.

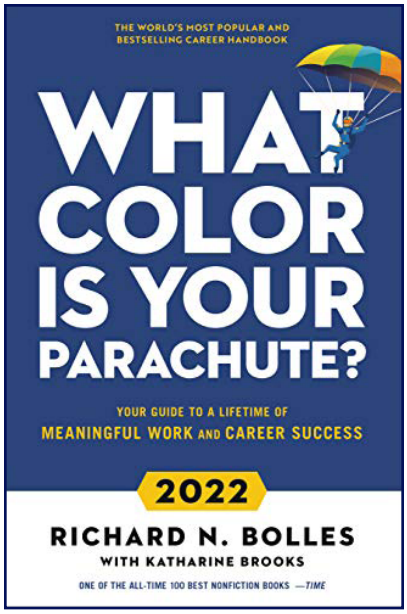
Exercise 10. Explore effective negotiation strategies with participants. Online negotiation guides are available from HBS, Udemy and the University of California-Santa Barbara, and can be found in books such as Effective Negotiation and Getting to Yes.

Exercise 11. Lead a discussion on ways to maximize online presence, using resources such as those provided by the *Nature* journal. Generate suggestions for connecting to one's field through subscriptions to newsletters and blogs, including general interest publications such as The Chronicle of Higher Education. Review and critique LinkedIn profiles and further discuss the use of social media in the sciences. Have participants Google themselves and ask whether the results accurately and fully represent their professional achievements.

Additional Resources

Books and Articles

1. What Color is Your Parachute?: Your guide to a lifetime of meaningful work and career success, by R.N. Bolles, 2022.
2. Improving the Postdoctoral Experience: An empirical approach, by Geoff Davis, 2009.
3. Alternative Careers in Science: Leaving the ivory tower, edited by Cynthia Robbins-Roth, 2006.
4. Yearly planning meetings: Individualized Development Plans aren't just more paperwork, by Ben J Vincent et al., 2015.
5. The Good Mentor by James B. Rowley, 1999.
6. Why Science Needs Strong Mentors (podcast), by Julie Gould, 2021.
7. Defining Mentoring: A literature review of issues, types, and applications, by Carol Mullen and Cindy Klimaitis, 2021.
8. The Science of Effective Mentorship in STEMM, by the National Academies of Sciences, Engineering, and Medicine, 2019.



Online Resources

10. Toolkits from the National Postdoctoral Association
11. Vision Statement Toolkit from Cascade
12. How to Write a Curriculum Vitae (With Examples) from The Balance
13. The Science of Effective Mentoring in STEMM from the National Academies
14. Career resources from the National Research Mentoring Network
15. Online presence guide from the University of the Free State
16. Academics' Online Presence: A four-step guide to taking control of your visibility from Academia
17. What is Your Digital Footprint? from The Academic Designer

2 Personal Effectiveness and Leadership

Introduction

This module incorporates four topics. First is *leadership*, which McKinsey defines as the identification and implementation of behaviors to help people align their collective work, execute strategies, and renew an activity, project or organization. Second is *professional and career development*, including career management, professional development, responsiveness to opportunities, networking, reputation and esteem. Third, *self-management* entails preparation and prioritization, commitment to research, time management, responsiveness to change, and maintenance of work-life balance. Finally, the module will discuss the *personal qualities* needed for leadership, such as enthusiasm, perseverance, integrity, self-confidence, responsibility, and the capacity for self-reflection.

Learning Objectives

1. Identify areas of personal effectiveness and understand how they relate to career and personal growth
2. Self-assess skills and values to evaluate leadership style and identify strengths and opportunities
3. Develop a 3-5 year career roadmap and identify skills to support advancement
4. Develop communication, people management, and supervisory skills
5. Identify and capitalize on leadership opportunities
6. Identify a support network to help develop personal effectiveness and career skills

This training focuses on taking stock of individual personal skills, values and strengths and identifying a suite of tools and resources to help develop a personal roadmap for a career in STEM fields. Included are a variety of activities that require learners to look inward, to actively develop and practice leadership skills, and to connect with others to create an effective and supportive network as they progress through the early stages of their careers.

Themes and Exercises

Theme 1: Personal Effectiveness and Leadership Style. Participants will expand the notion of personal effectiveness by developing a personal mission statement to guide decision making, and by defining personal values and how they align with particular career tracks. Participants will then explore skills and topics that relate to various leadership styles and understand how they help or hinder personal effectiveness.

Exercise 1. Have participants define their personal values through a card-sorting exercise, such as these found on Wikihow, Lifehack and Indeed, and share their findings with others.

Exercise 2. Have attendees participate in mindfulness practices, such these provided by the American Psychological Association, Elsevier and HBR. Learning to train one's attention and be present in the moment can improve mental and physical health.

Exercise 3. Invite participants to complete a leadership inventory, such as the one found in the book Strengths Based Leadership. Then ask participants to share what did and didn't surprise them about the results of their inventory. Next, ask participants to identify another participant with whom they share a top-five strength, and to take 10-15 minutes to discuss together what this particular strength means to them, how they use it, and how it serves or obstructs them. Finally, invite participants to find an individual who has a strength they do not have in their top five strengths, and to discuss with them their differences in strengths.

Exercise 4. Ask participants to generate a short list of challenges encountered in research or academic settings for which effective leadership is necessary. Examples might include negotiating a raise, addressing performance issues, or managing a conflict. Then ask participants to share at least one example with the group, making sure that the array of examples reflects a cross-section of research and academic domains.

Exercise 5. Ask participants to craft a statement of their leadership philosophy that reflects their personal skills and approach to leadership, prompted by these examples from Indeed and ASCD and building on results from exercises 3 and 4. This statement should reflect both strengths and limitations, and can be used to aid the participant in leadership problem-solving. Have participants share their statements with a small group of peers and work as a group to further refine them. Potentially offer a selection of sample challenges to elicit group discussion of how leadership identity helps shape strategies to address challenges.

Theme 2: Assessments and Roadmaps. Working individually or as a group, learners will identify their own personal strengths and how their skills align with career options. They will develop a personal plan for career development, including identifying and recognizing the influence of past experiences and hopes and dreams for the future.

Exercise 6. Have attendees take the Gallup Education CliftonStrengths assessment,which provides an individual with their "Top 5" strengths from a set of 34 strength themes. Focusing on these strengths on a daily basis has been shown to have positive effects on personal and professional well-being.

Exercise 7. Have participants read this *Science* article entitled Making the Leap to Independence and discuss the traits of flexibility, persistence, and self-confidence, which the authors highlight as necessary to achieve independence in a scientific research setting. Ask participants to reflect on their own experiences and where these traits have come into play.

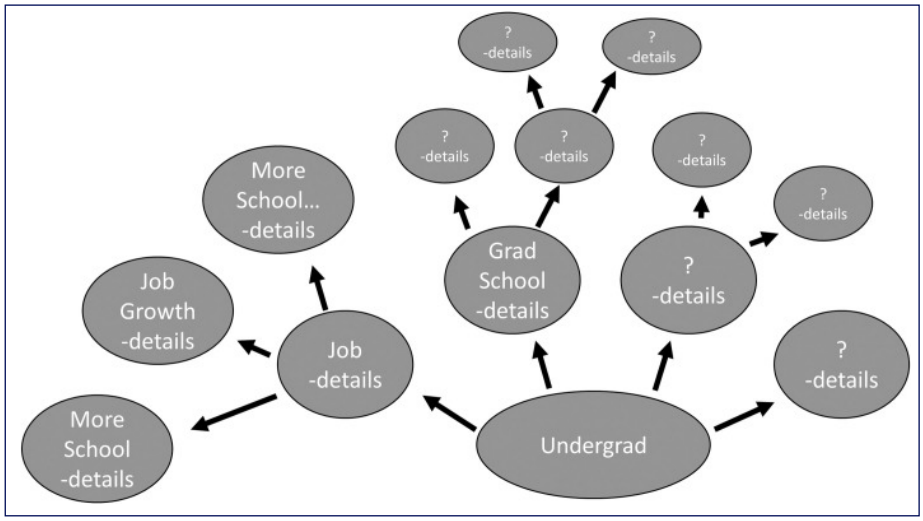


Figure 2.1 Future Life Map template. From Whitehead et al. (2022).

Exercise 8. Have participants build an Individual Development Plan on the AAAS myIDP platform to help them define and pursue their career goals (See the Career Management module for more information on IDPs.)

Exercise 9. Have students complete and share a "Future Life Map" (see Fig. 2.1) exercise such as those offered by WLGuidance, 50waystogetajob.com, and Marshall Books, and also review information about how life maps can highlight career opportunities for underrepresented minority undergraduates in STEM. Facilitators may wish to refer back to Strengths Based Leadership to refine their approach to this activity. Ideally, this exercise would dovetail with the development of the IDP as it helps participants identify where to invest more time into their career futures.

Theme 3: Communication and Leadership Opportunities. Participants will develop emotional intelligence in order to be an effective communicator, including building self-awareness, self-regulation and empathy. They will also explore the metrics used to determine their promotion through academic and research positions. Topics include the importance of international reputation, the need for preparation at early career stages, and prioritizing voluntary leadership opportunities at various levels.

Exercise 10. Have learners develop relevant communication skills through exercises from Positive Psychology.

Exercise 11. Divide learners into small groups to discuss and devise solutions to a series of example leadership challenges, such as peer-to-peer conflict as well as conflict between team members at different levels. Challenges should preclude clear "win-win" options, with potential pros and cons that may be perceived differently among team members. The exercise will elicit discussion of how to reach an informed decision and how to effectively communicate that decision.

Exercise 12. Have participants explore their own biases and privileges in terms of qualities such as age, gender, race, ethnicity, and socioeconomic status. Facilitate a discussion on what was learned from these reflections, and the role leaders have in building spaces for people from diverse backgrounds to thrive. Have participants write what is within their power to change or enact to support diversity, equity and inclusion, and encourage them to include this in their Individual Development Plan.

Exercise 13. Ask participants to identify 3-5 existing leadership opportunities within their domain of practice at the department level, the college/university level, and the national and/or international level. Have them identify where they can learn and demonstrate leadership skills and thus establish a national and international reputation. Have learners gather in small groups to develop a combined list of possibilities, then have individuals prioritize items at each of the three levels and identify which are most realistic to include in an IDP.

Theme 4: Support Networks. Participants will explore avenues for finding support networks to share and discover opportunities, to discuss topics that may be difficult to address with institutional peers, and to gather feedback on both personal and professional challenges.

Exercise 14. Have participants form peer groups to discuss and share options for support networks, including departmental, institutional, disciplinary, and professional organizations. Such groups can offer important opportunities for networking, peer support, and broadening perspectives. Suggest that participants make a commitment to a colleague to explore opportunities and to test one such group.

Additional Resources

Books and Articles

1. Guide to Your Professional Growth from Harvard Business Review
2. Managing Your Career from Harvard Business Review

Online Resources

3. Leadership programs from the Society for Advancement of Chicanos/ Hispanics & Native Americans in Science (SACNAS)
4. Leadership training from the National Institutes of Health
5. Workshops from the American Institute of Biological Sciences, including Enabling Interdisciplinary and Team Science, Communications Boot Camp, and Writing for Impact and Influence
6. Leadership Certificate from Cornell University
7. myIDP from Science.org
8. Leadership Development Resource Center from EAB
9. Communication Exercises and Games for the Workplace from Positive Psychology

3 Work-Life Integration

Introduction

Integrating one's personal and professional lives is critical for a postdoc's mental health and career success. This module will help participants reflect upon and articulate how they want to balance studies and employment with personal needs and interests, empowering them to then seek out operational techniques to achieve that integration and balance.

Themes and Exercises

Theme 1: Defining Work-life Integration. Participants will learn the definition of work-life integration and how it impacts wellness and productivity, as well as understand how it changes throughout one's life. Participants will explore the differences between work-life-integration and work-life-balance, and the implications of each.

Learning Objectives

1. Understand what is meant by work-life integration
2. Understand and utilize boundaries
3. Articulate barriers and supports to achieve a desired level of work-life integration, and create a plan for addressing barriers
4. Create a plan to assess alignment and integration in future job opportunities

Exercise 1. Have participants complete a Value Card Sort exercise (such as this online version) to identify the five values most important to them. This will give them a framework for prioritizing different aspects of one's job, as well as the language needed to make hard decisions about competing demands on one's time or other resources. Participants can then use these values as a lens for subsequent exercises.

Exercise 2. Have learners create an "ecosystem drawing" or "whole-life grid" (as described in the Chronicle of Higher Education) illustrating the interrelation of components of their work and life that they hope to integrate. This helps participants to see connections and points of conflict between these different elements.

Theme 2: Boundaries, Barriers and Supports. Boundaries - the limits, conditions, or rules that we set for ourselves - enable us to take responsibility for our own decisions and actions. Participants will learn how to develop and articulate their boundaries to enable them to know when (and how) to say "yes," "no," or "I'll get back to you." Conversations about setting and holding boundaries can be difficult, so this theme also teaches basic techniques to approach them. Participants will also articulate barriers and supports for integrating their personal, professional, cultural, and structural domains. Examples of barriers include family constraints, professional responsibilities, or financial considerations, and supports might include flexible work arrangements, supportive family members, and financial stability.

Exercise 3. Instruct participants in the OTFD (Observe/Think/Feel/Describe, aka Open The Front Door) method of approaching difficult conversations, as defined by Tasha Souza, Humboldt State University, and the Learning Forum. OTFD entails framing a situation in four sentences, which begin with "I have observed…", "I think…", "I feel…", and "Here is what I would like to be true in the future…". Have participants role-play several scenarios using this protocol.

To offer an example, let's say a PI has scheduled mandatory meetings on Saturday mornings, the only time of the week you can watch your daughter's soccer games. An OTFD response might be: "I notice that you have scheduled another mandatory Saturday morning lab meeting. I recall telling you about my family commitments, and I think this is causing grief in my household. I feel you are not treating me with respect or taking my personal situation into account. I would like to attend mandatory lab meetings at a different time or for there to be fewer scheduled for Saturday mornings."

Exercise 4. Ask participants to identify 3-5 barriers to work-life integration. Provide scenarios of work/life situations and ask learners to identify both key warning signs and successful strategies from the examples. Conduct role-playing exercises in which a postdoc must clear the air with a supervisor or family member with implicit (but unstated) expectations that create a barrier to work-life integration.

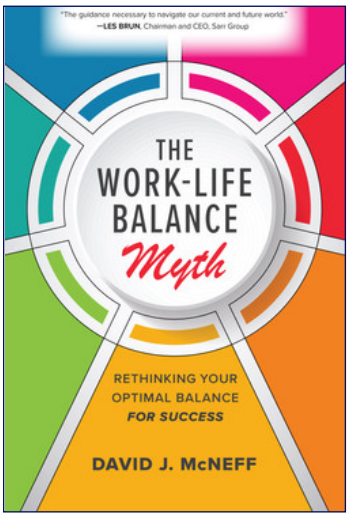
Theme 3: Planning, Resources and Opportunities. Participants will develop a plan and discuss available resources to address their identified barriers. This could involve looking at what kinds of positions offer the flexibility an individual values and needs, or the level of autonomy one wants in terms of job duties. This theme also includes basic time management techniques. Participants will create a plan to assess job opportunities through the lens of compatibility with one's personal values and goals, and the level to which the participant seeks to compartmentalize the different parts of their life. Activities will help learners to think about key work-life indicators present in job advertisements and interviews.

Photo by Jacob Lund Photography for the Noun Project

Exercise 5. Ask participants to reflect on what resources they need to achieve a favorable work-life balance or integration. These should include categories such as child care, financial resources, and personal and professional relationships. Have learners identify available resources through a search of their institution's website as well as relevant national organizations, and help them prepare an action plan to conduct such a search to identify places to seek employment.

Exercise 6. Provide an inventory of basic time management tools and techniques including planners, Individual Development Plans, etc., such as those referenced in Getting Things Done: The Art of Stress-Free Productivity by David Allen.

Exercise 7. Have participants review different job descriptions and look for clues for alignment with their desired work-life balance. Ask participants to identify and share questions they would ask in a job interview to learn more.



Additional Resources

Books and Articles

1. The Work-Life Balance Myth: Rethinking Your Optimal Balance for Success, by David G. McNeff, 2021.

Online Resources

2. Balancing the Scale: NSF's Career-Life-Balance Initiative
3. Video on work-life imbalance from the Chronicle of Higher Education
4. Blog entry on "Expecting Balance" from the Chronicle of Higher Education
5. Blog entry on "Where's the Fun in Funambulism" from the Chronicle of Higher Education

4 Fostering Creativity

Introduction

In research, creativity can be thought of as an intellectual ability to promote fruitful inquiry, take intellectual risks, develop new insights, and foster innovation. The content presented here supports training related to creativity that can be delivered in short period(s) during a single workshop or series of workshops. This module should be particularly relevant to postdocs in STEM fields and to biomedical researchers working in an academic setting.

Learning Objectives

1. Explore the meaning(s) of creativity and better understand and articulate its value
2. Foster individual attitudes that incorporate curiosity and a willingness to make mistakes, have fun, and generate new ideas
3. Learn to create an environment that fosters creative thinking and collaboration to overcome barriers

Themes and Exercises

Theme 1: What is Creativity? It is also important for individuals to understand what creativity is to them and to hear what it means to others. Under this theme, participants will learn to define creativity in the scientific process. Thinking about personally meaningful examples and developing one's own philosophy of creativity enables diverse ways of thinking and an appreciation for how it can enrich our professional endeavors.

We base our activities on two different definitions of creativity as described below. The first focuses on scientific creativity at the level of the individual, and the second on the social, physical, and cultural contexts in which scientific creativity occurs. The first definition was published in an 1890 article entitled The Method of Multiple Working Hypotheses by T.C. Chamberlin, a geologist, university president, and President of the American Association for the Advancement of Science.

> There are two fundamental classes of study. The one consists in attempting to follow by close imitation the processes of previous thinkers, or to acquire by memorizing the results of their investigations. It is merely secondary, imitative, or acquisitive study. The other class is primary or creative study. In it the effort is to think independently, or at least individually, in the endeavor to discover new truth, or to make new combinations of truth, or at least to develop an individualized aggregation of truth. The endeavor is to think for one's self, whether the thinking lies wholly in the fields of previous thought or not. It is not necessary to this habit of study that the subject-material should be new; but the process of thought and its results must be individual and independent, not the mere following of previous lines of thought ending in predetermined results.

Our second discussion of creativity in science focuses on the cognitive and cultural mechanisms that lead to scientific innovation. It comes from a 2009 book chapter entitled Conceptual Change: Creativity, Cognition, and Culture by Nancy Nersessian, Regents Professor of Cognitive Science at the Georgia Institute of Technology and Research Associate at Harvard's Mind Brain Behavior Initiative.

> The scientific "genius" who creates in isolation from social and cultural contexts is, indeed, a myth…"[T]hinking" is an inherently social and cultural activity. It rarely just goes on "in the head" in isolation from physical and social interactions. Even when a solitary thinker wrestles with a problem closed in her study, she is still engaged in a socio-cultural process. Educational training is present. Conversations with colleagues are recalled. Further, the process often involves external representation such as sketches and equations that are socio-cultural in origin…to produce scientific knowledge requires both sophisticated cognition and a rich socio-cultural environment."

These explanations share the insight that everyone can express creativity, and everyone can foster and participate in a creative environment.

Exercise 1. Group participants into pairs and ask them to interview each other about their own general ideas, examples, and experiences with creativity. Give each person at most 10 minutes to ask impromptu interview questions and 10 more minutes to respond to them. After interviews, the group should discuss some of the different definitions and perspectives of creativity emerging from the dialogue. One approach to this exercise is to pair interviewers with interviewees from different STEM disciplines. Another approach is to intentionally include people from predominantly creative disciplines to foster conversations that explore approaches and strategies for creativity from multiple domains. These exercises will help participants to doff their "armor of expertise" and identify room for creativity through exposure to a generalized space outside of their field.

Theme 2: Fostering a Creative Attitude. Exercises under this theme help participants to develop an attitude in which they can experiment, make mistakes, have fun, and generate ideas. People will learn to be creative through structured ad hoc and impromptu situations where they can explore ideas without critique or consequence. Creativity often occurs when we see things from a new perspective or think 'outside the box,' so activities will encourage appreciating diverse perspectives to foster creativity. Participants will also develop "handles" that people with different ways of knowing and thinking can grab onto, which can serve to foster innovation.

Exercise 2. Place participants in groups of two or three. Have one participant start by making a statement about something non-specialized. Ask the next person to respond with a related "yes, and" statement - they are not allowed to say "but" or "no" even if they disagree. Each person then takes a turn responding to the previous statement, up to a time limit. This accepting approach to communication is drawn from acting and improvisation and, in contrast to the "critique' model of dialogue, creates space for creativity to emerge.

Photo by Alia Youssef from Noun Project

Exercise 3. Instruct participants to walk around for a fixed time and apply what they experience with their senses to a problem they want to solve or an idea they are seeking to generate. For example, participants can be asked to develop metaphors to explain their projects, ideas, or challenges based on their sensory experiences during their walk. After walking, have each participant share with the group their idea, the metaphor(s) they developed, and how their experience while walking stimulated generation of each metaphor. Conclude with discussion of how intentional, scheduled "wandering" time is a strategy participants could implement on their own.

Exercise 4. Ask the entire group to brainstorm ideas about situations with competing goals. After a fixed amount of time, have the group vote on which ideas to use as prompts for the exercise. Split participants into pairs and give each pair one of the prompts. The two learners must ask each other questions and reach a negotiated agreement in regards to the competing goals. The negotiation should be conducted either within a set time or with a limited number of questions. The discussion will foster ad-libbing and impromptu thinking about one's own position and negotiation for a common good.

Theme 3: Strategies to Enhance Creativity. Self-validation or self-critique can significantly hinder creativity; taking action to understand and identify these barriers is a key to breaking through them. Just as physical exercise leads to more strength and new capabilities, so can exercises in creativity foster new ways of thinking by creating physical and virtual environments external to people's individual minds. Workshop participants will be guided to engage or play with various objects or ideas as part of the creative process, using their senses and experiences to gain knowledge from social and physical environments.

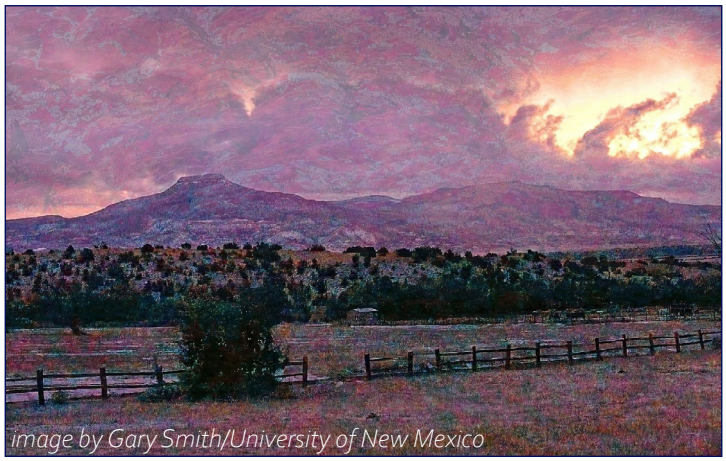


image by Gary Smith/University of New Mexico

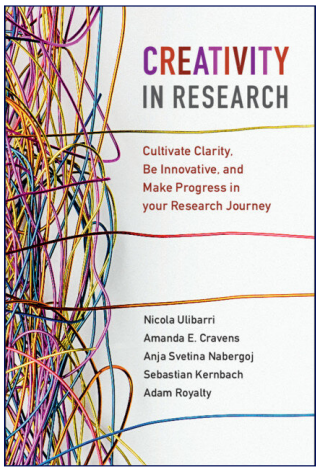
Exercise 5. Lead participants in using collaborative illustration, objects, or construction paper to explore, play, and create. One approach is to provide a small group with a concept that they collaborate to represent during a fixed time. For example, pairs or small groups can be given construction paper and instructed to craft a tree that represents spring or fall. Another approach is to provide small groups with materials and ask them to create anything they want within a fixed time. The focus of the exercise is to provide playful space for individuals to collaboratively explore ideas using non-verbal or written methods.

Exercise 6. Engage participants in "free writing" exercises. One possibility is a "zero drafting" activity in which participants free write to produce an outline or sketch of an entire topic. Another activity, following the article by Chamberlin excerpted above, challenges participants to generate as many alternative hypotheses as they can on a research question or topic. At the end of the exercise, each participant should share their reflections on the process of free writing: Was it difficult? Why or why not? Did they experience pauses in thought or did ideas flow freely? Were they able to set aside concerns about style, grammar, clarity, or logic? Did new ideas emerge from the process?

Additional Resources

Books and Articles

1. Creativity in Research, by N. Ulibarri, A. Cravens, A. Svetina Nabergoj, S. Kernbach and A. Royalty, 2019.
2. The Myths of Creativity: The Truth About How Innovative Companies and People Generate Great Ideas, by David Burkus, 2013.
3. Unlocking Creativity: How to Solve Any Problem and Make the Best Decisions by Shifting Creative Mindsets, by Michael Roberto, 2019.
4. Promoting Individual and Collective Creativity in Science Students, by Isabel Reche and Francisco Perfectti, 2020.
5. Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39, by Susan Star and James Griesemer, 1989.
6. Scientists Are More Creative Than You Might Imagine, by Alexandra Ossola, 2014.



Online Resources

7. The suggested reading list for Creativity in Research, a group of researchers and educators at Stanford University who offer insights, training, and resources to foster creativity.

Module Set B: Collaborating and Working with Others

Module Authors

5 Teaching

- Lead Authors: Gary A. Smith and Jo Ann Smith
- Contributors: Saranga Abeygunawardane, Donna C. Lewellyn, Oliver Myers, Frederick C. Harris and Qian Wang

6 Collaboration and Team Science

- Lead Authors: Paul D. Hirsch and Pips Veazey
- Contributors: Stephanie Galla, Kevin M. Gray, Frederick C. Harris, Amy Slocum and Rita Teutonico

7 Facilitation

- Lead Authors: Heather Balas and Selena S. Connealy
- Contributors: Sandra Blakeslee, Michele Casella, Donna C. Lewellyn, Amy Slocum, Rick Schumaker and William K. Michener

8 Integrating Diversity, Equity and Inclusion

- Lead Authors: April K. Heyward and Oliver Myers
- Contributors: Michele Casella, Stephanie Galla and Jon Wheeler

5 Teaching

Introduction

Effective teaching is a critical skill for postdocs, as instruction is often a central part of academic positions at research universities and colleges. This section serves as an introduction to teaching and learning concepts that research-focused postdocs should be aware of as they continue to develop as a teacher. It does not offer exhaustive coverage of any single topic, which is better obtained through an individual institution's dedicated teaching center (see Appendix 5.1 for a partial list of Teaching and Learning Support Centers at NSF EPSCoR institutions.)

Learning Objectives

1. Identify perspective and values using the Teaching Perspective Inventory (TPI), and link these to choices as a teacher
2. Evaluate and outline a course or class objective using the Backward Design approach and the three essential design questions
3. Recognize the most effective learning behaviors, and select and/or create generative learning opportunities
4. Describe the difference between individuated and integrated approaches to learning, and create an inclusive instructional plan for a course

Themes and Exercises

Theme 1: Developing a Teaching Philosophy. Identifying one's own beliefs and intentions in regards to teaching are foundational to an educator's role. These perspectives on teaching also underlie a teaching philosophy or teaching statement that is commonly requested as part of applications for faculty positions. Under this theme, participants will use a Teaching Perspectives Inventory to frame their approach to teaching as a starting point for continuing faculty development.

Exercise 1. Have participants complete the 45-item Teaching Perspectives Inventory (TPI) prior to attending, and encourage them to read the resulting web-generated report. At the workshop, split attendees into five groups around flip charts or whiteboards based on their dominant TPI perspective. At each station, have learners collaboratively compile a list of specific approaches to teaching that match that perspective, such as student activities, teaching strategies, assessment methods, etc. Encourage participants to explore the different stations and add ideas to the lists created by other teams. Debrief the group about the meanings of each perspective for teaching and learning. Offer this reflection and discussion prompt: What is revealed by differences in my Beliefs, Intentions, and Actions TPI subscores?

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 5.1. Teaching breakout session at the Postdoc Workshop.

Theme 2: Applying the Backward Design Approach. Wiggins and McTighe's Backward Design approach to teaching (as summarized by Bowen) starts with the end goal in mind, rather than with a list of topics or lessons. Asking oneself, "What do I want my students to understand and be able to do after they leave the course?" puts student learning at the center of course design, development, and delivery. A necessary second question is, "How do I know and measure if students have achieved the desired results?" The key is to find meaningful ways to evaluate students' achievements that are clearly aligned with the learning goals or desired results identified by answering the first question. The final question in the process is, "Which

learning activities will lead students to the desired results?" Answering this question helps to select and develop the most effective learning activities.

Exercise 2. Have participants analyze a Backward Design outline consisting of a learning objective along with student assessment strategies and a list of learning activities. Ask attendees to offer recommendations for improvements or alternative activities based on the Backward Design model, and discuss the alignment between assessments and activities and the desired learning outcomes.

Then, have learners develop and share a brief outline of a course plan, including learning objective, assessment and learning activities, using a Backward Design Worksheet (Appendix 5.2) from the University of Oregon or the Backward Design Framework Worksheet (Appendix 5.3) adapted by UC San Francisco. For a potential longer-term activity, have attendees design a course using the Backward Design Template (Appendix 5.4) - either a course they are teaching, or a foundational undergraduate course in their discipline. This project will take time and may require attendees to use existing learning objectives to design the course.

Theme 3: Teaching Choices that Maximize Learning. The goal of this theme is to provide participants with a research-based framework to guide them in designing learning experiences for students. Interest in replacing traditional lectures with active - and especially interactive - learning has been growing for 30 years, and is especially acute in STEM fields. "Active learning," however, has become a buzzword encompassing experiences that range widely in learning effectiveness. There is also an increasing emphasis on "generative learning," in which students create knowledge through problem-solving rather than recycle it by answering questions. A newly prominent teaching paradigm is the Interactive-Constructive-Active-Passive (ICAP) model, which forms a robust lens for educators to frame their choices in instructional strategies.

Rank (high to low) the depth and retention of learning anticipated from each activity	
A. Pairs of students examine graphs and figures that illustrate the properties of three metals in terms of elastic modulus, bond energy, and melting points, and then together complete a 5-question worksheet to demonstrate relationships between these properties.	B. Each student examines graphs and figures that illustrate the properties of three metals in terms of elastic modulus, bond energy, and melting points, and then completes a 5-question worksheet to demonstrate relationships between these properties.
C. Each student reads a text or listens to a lecture explaining relations between bonding energy, elastic modulus, melting points, and coefficient of thermal expansion concepts.	D. Each student reads a text that explains the relations between bonding energy, elastic modulus, melting points, and coefficient of thermal expansion concepts and is instructed to highlight the most important or critical sentences.

Table 5.1. ICAP examples. From Menekse et al. (2013).

Exercise 3. Ask small groups of participants to rank, in order of decreasing depth and retention of learning, the four activities listed in Table 5.1, which follow the ICAP model. (The correct order is A-B-D-C.) Have participants justify their choices and debate differences between participant teams. Then present the ICAP framework and ask participants to identify ICAP elements in the four student groups, followed by sharing the learning gains measured in the groups as support for ICAP.

Exercise 4. Engage attendees in further ICAP activities, such as having them view classroom videos and attribute ICAP characteristics to different learners or learner activities in the videos, with discussion. They could also create and discuss a mock classroom experience including presentation, solo student work, and small-group student work, with some participants acting as students and others observing. Additionally, participants can outline assignments that aim to stimulate constructive and interactive student behaviors, then gather in pairs or trios to discuss and critique each other's examples.

Theme 4: Inclusive Teaching and Learning. The goal of this theme is to provide participants with a research-based framework with which to design inclusive learning experiences for diverse students, building on Chavez and Longerbeam's Teaching Across Cultural Strengths. Learners will come to understand how cultural experiences contribute to the different ways that knowledge originates and learning occurs. Recognizing

these differences and designing learning experiences along a spectrum of opportunities is most likely to match the collective expectations of the students and lead to stronger outcomes.

Exercise 5. Engage students in the "How do you enter the learning process" worksheet adapted from Chavez and Longerbeam (Appendix 5.5). This worksheet helps delineate the difference between individuated learning, which favors a compartmentalized, private, conception of the world, and integrated learning, which favors an interconnected, mutual, contextually dependent worldview. Without revealing the column headings, have individuals mark an "X" in each row to represent their values and preferences along the continuum between the two options. Compile results on a single chart to show the range of responses among the participants, and discuss where those differences arise. Then reveal the Individuated and Integrated column headings and their origin in different cultural constructs of learning and teaching. Have participants suggest approaches to teaching that are more inclusive of the Integrated construct, which is usually de-emphasized in college teaching.

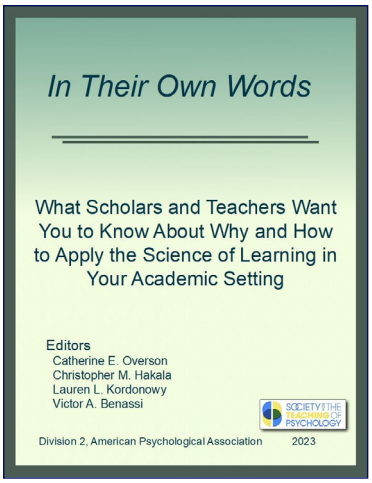
Exercise 6. Explain and share data from a published paper, such as those by Eddy and Hogan, Haak et al., or Theobald et al., that demonstrate teaching approaches that diminish achievement disparities ("achievement gaps") between students from different backgrounds. Have participants propose why the individuated and integrated cultural constructs remedied the achievement disparities.

Exercise 7. Have participants complete the "The Learning Climate" table (Appendix 5.6.) Filling this out enables each participant to generate ideas for inclusive teaching and learning experiences.

Additional Resources

Books and Articles

1. Active-constructive-interactive: A conceptual framework for differentiating learning activities, by Michelene T.H. Chi, 2009.
2. Applying the ICAP Framework to Improve Classroom Learning, by Michelene T.H. Chi and N.S. Boucher, 2023. In In Their Own Words: What scholars and teachers want you to know about why and how to apply the science of learning in your academic setting.



3. Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom, by L. Deslauriers et al., 2019.
4. Active learning increases student performance in science, engineering, and mathematics, by S. Freeman et al., 2014.
5. Beyond affirmative action: Reframing the context of higher education, by Robert A. Ibarra, 2001.
6. Differentiated overt learning activities for effective instruction in engineering classrooms, by M. Menekse et al., 2013.
7. Five Perspectives on Teaching in Adult and Higher Education, by Daniel Pratt, 1998.
8. Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students, by N.M. Stephens et al., 2012.
9. Understanding by Design, by Grant Wiggins and Jay McTighe, 2005.

Online Resources

10. Understanding by Design summary, by Ryan Bowen, 2017.
11. A Self-directed Guide to Designing Courses for Significant Learning, by L. Dee Fink, 2003.
12. Design and Teach Your Course, from Carnegie Mellon's Eberly Center for Teaching Excellence.

Appendix 5.1 Partial List of Teaching and Learning Support Centers at NSF EPSCoR Institutions

Alabama

- Alabama A&M University: Centers of Excellence in Teaching and Learning
- Auburn University: Biggio Center
- Tuskegee University: Office of Distance Education and Online Learning
- University of Alabama: Office of Teaching Innovation and Digital Education
- University of Alabama in Huntsville: Enhanced Teaching & Learning Center
- University of Alabama at Birmingham: Center for Teaching and Learning
- University of South Alabama: Innovation in Learning Center

Alaska

- University of Alaska Anchorage: Faculty Development and Instructional Support
- University of Alaska Fairbanks: Faculty Accelerator

Arkansas

- University of Arkansas: Wally Cordes Teaching and Faculty Support Center
- Arkansas State University: Center for Excellence in Teaching and Learning
- University of Arkansas at Little Rock: Academy for Teaching and Learning Excellence
- University of Arkansas for Medical Sciences: Center for Faculty Excellence
- University of Arkansas at Pine Bluff: Center for Teaching and Learning
- University of Central Arkansas: Center for Excellence in Teaching and Academic Leadership

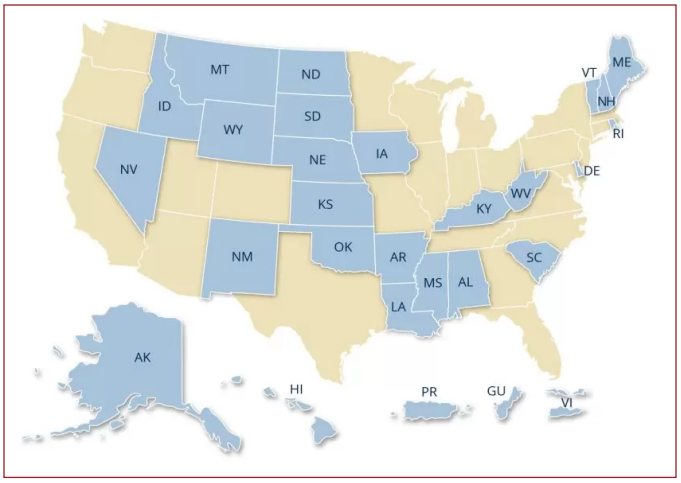


Figure 5.2. EPSCoR states and jurisdictions as of 2023.

Delaware

- Delaware State University: Center for Teaching and Learning
- Delaware Technical Community College: Center for Creative Instruction and Technology
- University of Delaware: Instructional Design Services

Guam

- University of Guam: Global Learning and Engagement Office

Hawaii

- University of Hawai'i at Mānoa: Center for Teaching Excellence

Idaho

- Boise State University: Center for Teaching and Learning
- Idaho State University: Instructional Technology Resource Center
- University of Idaho: Center for Excellence in Teaching and Learning

Iowa

- Drake University: Center for Teaching Excellence
- Iowa State University: Center for Excellence in Learning and Teaching
- University of Northern Iowa: Center for Excellence in Teaching and Learning
- University of Iowa: Office of Teaching, Learning, & Technology

Kansas

- University of Kansas: Center for Teaching Excellence
- Kansas State University: Teaching & Learning Center

Kentucky

- University of Kentucky: Center for Enhancement of Learning and Teaching
- University of Louisville: Delphi Center for Teaching and Learning
- Morehead State University: Faculty Center for Teaching & Learning
- Murray State University: Faculty Development Center

- Northern Kentucky University: Center for Teaching and Learning
- Eastern Kentucky University: Faculty Center for Teaching & Learning
- Western Kentucky University: Center for Innovative Teaching and Learning

Louisiana
- Louisiana State University: Center for the Integration of Research, Teaching and Learning
- Louisiana Tech University: Center for Instructional Technology
- Loyola University New Orleans: Center for Teaching, Research, and Learning
- Tulane University: Center for Engaged Teaching and Learning

Maine
- University of Maine: Center for Innovation in Teaching and Learning

Montana
- Montana State University: Center for Faculty Excellence
- Montana State University Billings: Center for Teaching and Learning
- Montana State University Northern: Office of Teaching and Learning Excellence
- Great Falls College: Teaching and Learning Center
- University of Montana: Teaching Excellence Initiative
- Montana Technological University: Center for Academic Innovation

Nebraska
- University of Nebraska-Lincoln: Center for Transformative Teaching
- University of Nebraska-Omaha: Center for Faculty Excellence

Nevada
- Nevada State College: Center for Teaching and Learning Excellence
- University of Nevada Las Vegas: UNLV Faculty Center

New Hampshire
- University of New Hampshire: Faculty Development Programs

New Mexico
- University of New Mexico: Center for Teaching and Learning
- New Mexico Institute of Mining and Technology: Faculty Development Programs

North Dakota
- North Dakota State University: Office of Teaching and Learning
- Dakota State University: Center for Teaching and Learning

Oklahoma
- University of Oklahoma: Center for Faculty Excellence
- Oklahoma State University: Center for Teaching & Learning Excellence
- University of Central Oklahoma: Center for Excellence in Transformative Teaching & Learning

Puerto Rico
- University of Puerto Rico: Academic Mentoring Office and Faculty Development Program

Rhode Island
- Rhode Island College: Faculty Center for Teaching and Learning

South Carolina
- University of South Carolina: Center for Teaching Excellence

South Dakota
- South Dakota State University: Teaching Learning Center
- Black Hills State University: Center for Teaching and Learning

U.S. Virgin Islands
- University of the Virgin Islands: Center for Excellence in Teaching & Learning

Vermont
- University of Vermont: Center for Teaching and Learning
- Northern Vermont University: Center for Teaching and Learning

West Virginia
- West Virginia University: Teaching and Learning Commons

Wyoming
- University of Wyoming: Ellbogen Center for Teaching and Learning

Appendix 5.2 Backward Design Worksheet

What is Backward Design?

Planning a course through Backward Design (also known as *Integrated Course Design*) is a three-step process. First, the instructor articulates objectives, also called *learning outcomes*. They then identify what assessments, such as exams or papers, will ensure students meet those goals. Only after completing these two steps does the instructor select specific class activities and access to content.

Why should I use Backward Design?

Backward design helps us focus on what matters most: the changes our courses make in how our students think, act and feel. It's easy to think first of content (I'll give a lecture on this subject; students will read that textbook) and to lose sight of larger goals that involve how students move forward from our classes into other studies, into professions, and into their future lives. What impact do we want to have, and can we be intentional about getting our students there?

How to implement Backward Design

First, think broadly about what you care about most deeply in terms of student learning. In *Creating Significant Learning Experiences* (2003), Dee Fink suggests addressing three questions: "In your deepest, fondest dreams, what kind of impact would you most like to make on your students? A year or two after this course, what would you like to be true for your students that is not true for others? What is the distinctive educational impact your teaching and courses should have on students?"

Next, as you think about more specific learning objectives, consider a full range of possibilities. Here are some examples, also from Dee Fink:

- *Foundational Knowledge*. What do I want my students to know?
- *Application*. What do I want my students to be able to analyze, evaluate, calculate, critique, etc.?
- *Integration*. What kinds of connections do I want my students to be able to make: between my course and another, my course and the broader field, my course and their everyday lives, etc.?
- *Human Dimension*. How do I want my students to grow in their understanding of themselves or others? What are personal and social stakes of my class?
- *Caring*. Do I hope my students come to care about something more? How might the course impact their feelings, interests, and values?
- *Learning How to Learn*: Have my students learned something about the process of learning itself that will help them in other courses and environments?

This material was created in Fall 2017 by the University of Oregon Teaching Engagement Program.

Appendix 5.2 Backward Design Worksheet (continued)

Instructor Planning Steps

1

What should students know or be able to do?
(i.e. What is the learning outcome?)

2

How do students demonstrate what they know or can do?
(i.e. What kind of assessments will be used?)

3

How do students prepare for demonstrating their knowledge or skills?
(i.e. What activities, interactions, etc. will they engage in?)

4

How do students engage with the content they'll be using?
(i.e. How will they retrieve or receive the content?)

4 3 2 1

Student Learning Experience

Appendix 5.3 Backward Design Framework Worksheet

Stage of Design	Guiding Questions	Notes
1. Identify Desired Results	What do you want students to learn, achieve, or be able to do? Do you need to revise your goals given the circumstances? What goals are absolutely necessary? Which are flexible? Can you establish curricular priorities to simplify and clarify the learning outcomes for your students?	
2. Determine Acceptable Evidence	How will you know if students met your goals? What are you going to accept as evidence of their learning or proficiency? Do you need to adjust how you assess your students given limitations you may be facing? Can you be flexible with how students demonstrate their learning to accommodate for diverse learning styles?	
3. Plan Learning Experiences and Instruction	How do you get students there? What enabling knowledge (such as facts, concepts, and principles) and skills (such as processes, procedures, and strategies) will students need to achieve desired results? What learning activities will support or facilitate their learning? What will you need to teach to meet performance goals, and how should it best be taught? What materials and resources are best suited to accomplish these goals? (Note: consider both asynchronous and synchronous methods. Do they need to do undertake activities together, or can they move at their own pace?	

Developed by Isaac J.T. Strong, University of California San Francisco Graduate Faculty Development Program (2020). Adapted from Understanding by Design (2017) by Ryan Bowen, Vanderbilt University Center for Teaching.

Appendix 5.4 Backward Design Template

Stage 1: Desired Results

Established Goals

The enduring understandings and learning goals of the lesson, unit, or course.

Transfer

Students will be able to independently use their learning to…

How students will transfer the knowledge gained from the lesson, unit, or course and apply it outside of the context of the course.

Meaning

Understandings	**Essential Questions**
Students will understand that… *The big ideas and specific understandings students will have when they complete the lesson, unit, or course.*	*The provocative questions that foster inquiry, understanding, and transfer of learning. These questions typically frame the lesson, unit, or course and are often revisited. Students should be able to answer the question(s) if they reach the established goals.*

Acquisition

Students will know…	Students will be skilled at…
The key knowledge students will acquire from the lesson, unit, or course.	*The key skills students will acquire from the lesson, unit, or course.*

Stage 2: Evidence and Assessment

Evaluative Criteria

The various types of criteria upon which students will be evaluated.

Assessment Evidence

Performance Task(s)

The task(s) students will complete to demonstrate the desired understandings or attainment of goals. Task(s) are typically larger assessments like projects or papers that coalesce various concepts and understandings.

Other Evidence

Other types of evidence that indicate if students have achieved the desired results. These include quizzes, tests, homework, etc. Also consider incorporating self-assessments and student reflections.

Stage 3 – Learning Plan

Summary of Key Learning Events and Instruction

The individual learning activities and instructional strategies that will be employed. These include lectures, discussions, problem-solving sessions, etc.

Appendix 5.5 The Learning Process

How do you enter the learning process? Where do you fit in this table?

Ways of knowing, sources of knowledge, preferences for learning, roles of teachers and learners and other aspects of the learning process vary among people. These differences largely stem from life experiences and the cultural context and identity of the learner. For each row in this table, use an 'X' to mark the location within the gray box that represents where you fit on the continuum between the descriptions at each end. Note this isn't a binary response, so your preference for some items may lie between the two extremes.

Personal System A	⟷	Personal System B
Knowledge, individual competence, examining ideas are highly valued	**Purpose of Learning**	Wisdom, betterment of the lives of those with whom we are connected, and real-world application of knowledge are most valued
Through the mind	**Ways of Taking in Information**	Through mind, body, spirit, intuition, emotions, and relationships
Verbal, linguistic, logical, mathematical, spatial, and linear thinking	**Ways of Making Sense**	Visual, intuitive, spiritual or natural, interpersonal, storytelling; nonlinear and relational thinking
Compartmentalized and separate; belief that understanding how parts work separately, abstractly, and in isolation will lead to the greatest understanding	**Interconnectedness of What is Being Learned**	Contextualized and connected; belief that understanding how things effect each other within the whole, pragmatically, and within community will lead to understanding
Learning is a private, individual activity; an individual is responsible for one's own learning; personal space is private	**Space, Privacy, Responsibility**	Learning is a collective, shared activity; an individual is responsible for their own and others' learning; personal space is shared
Unconscious of cultural traits related to teaching and learning	**Cultural Consciousness**	Conscious of cultural traits related to teaching and learning
Time is linear; a commodity that is spent, wasted, or saved; to be on time shows respect; meeting deadlines is most important	**Time**	Time is circular or seasonal, dependent on relationships, awareness and context; to allow for enough time shows respect; accurate completion most important
Task-oriented; success evaluated by how the task was completed; focus on outcomes and objectives	**Learning Success**	Process-oriented; success evaluated by how cohesively the group conducts the work
Provider and evaluator of knowledge; a few best perspectives and ways of learning; predetermined or bounded	**Role of Instructor or Control**	Facilitator of learning experience; multiple perspectives and ways of learning; emergent or constructivist
Primarily between teacher and students; primarily reliant on explicit verbal messages, direct communication of facts and concepts	**Interactions and Communications**	Involving a wide variety of interactions between students and between teacher and students; high use of nonverbal and multiple streams of communication; incorporates stories

Based on Web-Based Teaching and Learning across Culture and Age by Fengfeng Ke and Alicia Fedelina Chavez (2009) and Beyond Affirmative Action: Reframing the Context of Higher Education by Robert A. Ibarra (2001).

Appendix 5.6 The Learning Climate

Learning organization, design and assessment very widely among instructors, but typically vary little for an individual instructor. In contrast, learners bring diverse backgrounds, capabilities, and traditions of learning that may not be wholly compatible with a teacher's narrow range of instructional choices. How teachers intend learning to occur and how that learning is assessed can be viewed as being more or less inclusive of different types of students and more or less accessible for all learners, while also minimizing or maximizing the opportunities for students to learn from their diverse peers. For each of the rows in this table, mark where most of your learning experiences plot on the inclusivity spectrum.

Less Inclusive	⟷	More Inclusive
Lectures primarily use verbal explanation along with writing on board or text-rich PowerPoint		Lectures mix visual representation of data, images, and/or pictures with verbal explanation and text
Students apply concepts through individually completed assignments		Students apply concepts in collaborative assignments
Instructor uses one type of classroom teaching method, usually lecture		Instructor regularly integrates a variety of active-learning exercises and formative assessment tools into classroom
Instructor uses one type of exam question format, i.e. all multiple-choice		Exams include multiple question formats
Assessment provided with minimal or no feedback		Assessment is accompanied by explicit feedback
Grades assigned on a curve		Grades are assigned according to achievement of stated outcomes
Grades based mostly on a few individually completed high-stakes exams and/or assignments		Grades based on a variety of learning measures ranging from low-stakes, formative assessments to high-stakes exams and/or assignments; both collaborative and individual work
Instructor's questions always have a "right " answer		Questions have many correct answers and require group's consensus or collective knowledge
Individual work is required; it is undesirable for students to work together on problems		Substantial time provided for students to collaborate on answers
Students from underrepresented groups are grouped together or completely separated		Groups are ethnically and gender-diverse
Presentations, assignments and assessments focus on mastery of theory and general principles of the field		Presentations, assignments and assessments focus on practical applications of theory and general principles of the field
Learners are told how to interpret illustrations, data tables and photos		Students have opportunity to make sense of illustrations, data tables, and photos on their own or with others
Lessons focus on learning from examples and experiences selected by teacher		Lessons provide opportunities for students to relate ontent to their lives
Course does not include narratives of how people use or develop concepts learned		Course includes narratives of how people use or develop concepts learned
Scientists in examples are all or nearly all white men		Eaxmples include contributors to science of various ethnicities, races and genders
Students are "cold called" to answer questions		Students have opportunity ro reflect upon and discuss questions with peers
The same few students volunteer or are called upon to answer questions		Answers and contributions are requested and encouraged from all students
Many analogies are drawn from limited subject areas such as sports, militarty or construction		A broad range of analogies are used

Adapted from Scientific Teaching by Handelsman, Miller, and Pfund (2007), Motivating and Maximizing Learning in Minority Classrooms by Irene Sanchez (2000), and Diversity and Motivation: Culturally Responsible Teaching by Wodkowski and Ginsberg (2003).

6 Collaboration and Team Science

Introduction

This module focuses on the big picture of research collaboration: its benefits to researchers and the communities they are a part of; the conditions for successful and rewarding research collaboration; and the professional capacities one can develop and leverage as a participant in collaborative research at multiple levels. Collaborative research offers numerous distinct benefits:

Learning Objectives

1. Articulate the value of collaborative research
2. Understand and contribute to conditions for successful and rewarding collaborative research
3. Identify ways to develop and leverage collaborative research capacity

- For individual researchers, collaborative research offers opportunities for networking, capacity development, and the generation of high-impact publications.
- At the institutional level, collaborative research enables the leveraging of institutional capacities to achieve research aims that might otherwise be out of reach.
- For fields of knowledge, collaborative research initiatives can enhance knowledge creation, generate new fields of study, and provide opportunities for public engagement and education.
- For society broadly, collaborative research can foster and exemplify the values of inclusion, citizenship, and working across boundaries, for example between academia and practice.

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 6.1. Group session at the Postdoc Workshop.

The intention of this module is to provide key concepts and supporting, actionable exercises that a diverse array of people may use to generate forward progress in their collaborative research undertakings – regardless of where they are in their own development as research collaborators.

Themes and Exercises

Theme 1: Conditions for Successful Collaborative Research.
Collaboration planning at the beginning of a project is an important step in identifying a team's culture, setting expectations, and developing a practice of respectful communication. Furthermore, when a team creates its own plan, team members take ownership in the development and implementation of this guiding document. Identifying a facilitator to lead the co-creation of a team collaboration plan is a common practice. Activities under this theme detail the process of developing a collaboration plan, identify existing professional development offerings to advance facilitation skills, and share basic exercises that can help group members better work together.

Exercise 1. Have participants address the below set of questions, designed to help set the stage for collaborative research. In preparing for a collaborative research undertaking, it can be helpful for individuals and groups to use prompts such as these to explore their pre-existing experiences with collaborative research, and to set goals for new collaborative initiatives. This lays the groundwork for broad buy-in and sets the stage for overcoming future barriers.

- What is your personal experience with research collaboration?
- Identify the characteristics of good teams and bad teams that you have experienced. What constitutes a bad team and what constitutes a good team? How might you amplify the good and downplay the bad?
- What barriers do you think may come up in the course of collaborative efforts? Do you have ideas for overcoming them?
- What strengths do you bring to a research collaboration? In what areas do you see opportunities for growth?
- In thinking ahead to the upcoming collaboration, what do you see as the importance of the effort for you as an individual? For your institution? For the fields of knowledge represented? For society more broadly?

Exercise 2. Guide participants through basic exercises in facilitation, such as those found in the Facilitation module as well as those provided by Exaptive. The ability to facilitate effective meetings is a critical skill for collaborative research and also translates well to many different academic research settings. The role of a facilitator can be assumed by a team member with deep knowledge about the research; on the other hand, an external facilitator can be just as effective and allow all team members to take part in the conversations as participants, regardless of their role on the team.

Exercise 3. Have participants identify the elements of a draft collaboration plan that can be used as the guiding document for a collaborative science project - either a sample project, or an actual project attendees will participate in. Such plans contain guidelines on topics such as roles and responsibilities, resource allocation, and communication schedules. For source material see Comprehensive Collaboration Plans: Practical considerations spanning across individual collaborators to institutional supports by Hall et al. (2019). Also examine the poster "Ten components of the Collaboration Plan" by Hall et al. (2015), and use each element as a prompt for a discussion about the challenges and opportunities that your team might encounter.

Integration experts:
1. Combine a wide range of perspectives from different disciplines (i.e., interdisciplinary integration), as well as from research, policy, and practice (i.e., transdisciplinary integration).
2. Specialize in leading, administering, managing, monitoring, assessing, accompanying, and/or advising others on integration within inter- and transdisciplinarity projects or programs
3. Build bridges: Bring different people together, establish relations with them, and build bridges among them
4. Cross boundaries: Navigate social boundaries and successfully embed within social groups that embody different perspectives to be integrated
5. Translate: Discuss, reflect on, and translate different perspectives and ask pertinent questions to render explicit the uncertainties and assumptions underlying such perspectives
6. Catalyze: Identify potential tensions between different perspectives, leverage potential synergies between them, and generate new knowledge by recognizing critical connections
7. Facilitate: Design, plan, implement, and facilitate integrative processes, assign roles and responsibilities, and support generation of integrated outputs
8. Contribute: Provide intellectual contributions to scholarship by, for instance, linking theoretical concepts, co-creating integrative frameworks, or developing interdisciplinary methods
9. Advise: Provide opportunities for learning, practicing, and teaching integration, as well as accompanying, supporting, or coaching others in leading integrative processes and reaching integrated outputs
10. Mediate: recognize power imbalances and interpersonal conflicts within and between different social groups and deal with the implications as transparently, methodically, and consciously as possible

Table 6.1: 11 Roles of Integration Experts, after Hoffmann et al. (2022).

Exercise 4. Have participants develop a conceptual diagram to link various elements of the collaborative research substance and/or process. The diagram should 1) connect to the foci of the work; 2) have "handles" for everyone on the team; 3) be able to be used to formulate sub-teams and work-plans; 4) be able to be "played with" and used to ask questions and generate hypotheses; and 5) be motivating, interesting, and provocative. The diagram should serve as a "boundary object" - an object that is meaningful to thinkers working across a social or intellectual boundary. Such objects help enable the negotiation of ideas and concepts across the boundaries of language, discipline and culture, and become the launching pad for experimentation and innovation.

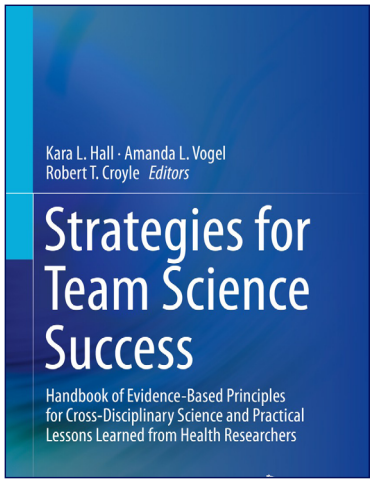
Theme 2: New Roles and Careers in Collaborative Research. Students have opportunities to pursue a wide range of career options that either did not exist or were less prevalent a couple of decades ago. Roles like boundary spanners, research facilitators, executive interdisciplinary scientists, community liaisons, and integration experts are increasingly included on large research teams and identified as key personnel in associated proposals (see Table 6.1). People serving in these positions are adept at helping team members to develop a shared understanding of their collaborative work and articulating the interdependencies among team members, both of which may evolve over time. The skills needed for this work are directly related to the competencies required to lead and manage interdisciplinary teams: program management, external and internal team communication, shared leadership, and both personal and social competence. Other important skills include negotiation, facilitation, communication, fiscal and personnel management, and leadership.

Exercise 5. Have participants reflect on what skills and expertise they would like to develop to succeed in collaborative research. Then ask them to peruse the list of professional networks listed in the "additional resources" section of this module, below. Discuss key opportunities with attendees, such as upcoming conferences focused on topics such as interdisciplinarity, research leadership, or integration and implementation.

Additional Resources

Books and Articles

1. Best Practices for Collaboration in Research, by Lucy M. Delgadillo, 2016.
2. Research Integration and Implementation, by Gabriele Bammer et al., 2020.
3. Integrate the integrators! A call for establishing academic careers for integration experts, by Sabine Hoffmann et al., 2022
4. Facilitating Collaboration Across Disciplinary and Sectoral Boundaries: Applications of a four-step strategic intervention, by Whitney Lash Marshall et al., 2017
5. Comprehensive Collaboration Plans: Practical considerations spanning across individual collaborators to institutional supports, by Kara L. Hall et al., from Strategies for Team Science Success, 2019.



Online Resources

6. International Network for the Science of Team Science
7. The Association for Interdisciplinary Studies
8. Center for Scientific Collaboration and Community Engagement
9. INTEREACH Interdisciplinary Integration Research Careers Hub
10. Team Science Collaboration Planning at the University of Wisconsin
11. Science of Team Science at the National Academies
12. The Toolbox Dialog Initiative at Michigan State University
13. The Network for Transdisciplinary Research at the Swiss Academy of Arts and Sciences
14. Professional Associations and Networks list by the ITD Alliance
15. Team Scholarship Acceleration Lab at the University of California-Irvine
16. Workshops on team science by the American Institute of Biological Sciences

7 Facilitation

Introduction

This module addresses the knowledge and skills that a postdoc should develop in order to facilitate successful face-to-face and virtual meetings, which are a mainstay of both academic and non-academic environments. This module will help participants to develop the baseline knowledge and skills needed for facilitation, and set them on the path toward developing their own facilitation style. These knowledge and skills provide a foundation for longer-term and more in-depth collaborations as described in the Collaboration and Team Science module.

Learning Objectives

1. Understand the value of facilitation and reflect on personal facilitation style
2. Develop skills and methods for facilitating equitable and productive discussion
3. Identify productive meeting structures
4. Learn facilitation techniques to generate and prioritize ideas

Themes and Exercises

Theme 1: Facilitator Roles, Characteristics, and Content Expertise. A skilled facilitator has the ability to listen to others and know when to speak up or stay quiet. They employ different strategies to ensure that all voices are heard and respected and are able to redirect and keep participants focused on the goals of the meeting. They seek to minimize interpersonal conflict and maximize intellectual discourse. Facilitation is perhaps most visible during a meeting, but the role of a facilitator is equally important before a meeting when agendas are set, participants are invited, and structures and processes are determined, as well as after a meeting to communicate action steps and hold participants accountable.

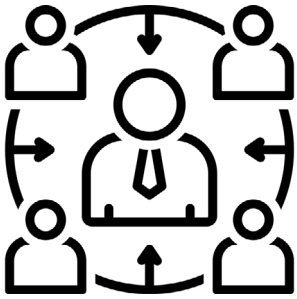
People with many different types of personalities can be good facilitators, and facilitation traits and mindsets can be learned and cultivated.

Some may mistakenly believe that a facilitator must be gregarious and extroverted. In reality, people with many different types of personalities can be good facilitators, and facilitation traits and mindsets can be learned and cultivated. Most importantly, facilitation is about valuing the perspectives of the people in your group. When facilitators demonstrate that they are authentically invested in amplifying the perspectives of the group, the participants generally sense that commitment.

Sometimes "experts" are resistant to structured facilitation. As participants, they may come to a group with the viewpoint that they know the content and don't need tools like sticky notes or a digital whiteboard. When asked to lead a group, they often lean on their expertise at the expense of considering process or factoring in time for unexpected ideas. This is not to say that content experts can't become good facilitators, but they sometimes have to make conscious decisions to set aside their biases and choose to develop a broader set of skills.

Exercise 1. Lead a "Think, Pair, Share" discussion in which participants generate important traits and mindsets of good facilitators. First, ask participants to think about someone they have observed to be a good facilitator. What did they do that was especially effective? What mindset or traits did they exhibit? Give participants a few minutes to jot down their answers, then another few minutes to share their ideas with a partner. Ask the group for examples, then ask the group to consider how they think those mindsets, traits, and skills were developed. You should emphasize that many, if not all, of the traits can be developed through deliberate practice and mentoring. Optionally, ask participants to pick one skill to develop in themselves and come up with a plan for exploration and practice.

Exercise 2. Have participants read and discuss an article about facilitation from the popular press. Much of the knowledge and expertise about facilitation can be found in the gray literature of websites, blogs, and magazines. Use search terms such as "effective meetings," or "facilitation tips" to identify good resources. (Try "Institute of Cultural Affairs" for a good source that is aligned with this module.) Assign different articles to small groups to discuss, then mix up the groups to share their insights with one another.



WEBTECHOPS LLP from Noun Project

Theme 2: Skills and Tactics for Facilitating Equitable and Productive Discussion. Important facilitation skills include management of time, people, and notes, as well as the ability to hold people accountable. The cardinal rule of facilitating meetings is to start and end on time. A facilitator should prepare all materials and agendas in advance and also prepare the room in advance, ideally structured so that no one's back is to another person. When planning a meeting agenda, estimate how long each element will take and err on the side of allocating more time than you expect to need. No one will complain if the meeting ends early! Review the agenda in advance with the group, asking if they believe you've allocated appropriate lengths of time. It can be helpful to decide, at the beginning, whether the group is willing to hold a follow-up meeting if needed. Keep track of time and ask someone to be your timekeeper if you are not confident about managing all the parts of the meeting. If you reach the end of the scheduled time and haven't achieved your meeting goals, refer back to the decision you reached at the beginning of the meeting. Will an extra 10 minutes wrap things up, or is another meeting needed?

There are three distinct elements to managing people in meetings: listening, inviting, and redirecting. Before you begin the meeting, decide how you plan to collect people's ideas. (See Theme 3, below, for sample approaches.) Regardless of which structure you deploy, an easy way to ensure an inclusive discussion is to offer a starter question and say: "We are going to give everyone the chance to speak once before anyone speaks twice." Then, as the discussion unfolds, invite opinions from people who have spoken less. Even when you use these approaches, you will still likely need to occasionally redirect. Redirecting people who get off track, dominate conversations, or say rude or provocative things may be the thing that novice facilitators fear the most. Consider the words you use as well as your body language. See the box for common strategies for redirection.

Strategies for Redirection

- Stand next to the person who talks too much.
- Use humor, e.g. "I'm going to be the mean timekeeper."
- Ask the group to respond to a provocative or disruptive idea raised by a participant.
- Use a summarizing strategy to interrupt an over-talker, e.g., "Can you sum up what you are saying so we are all clear?"

A fantastic meeting is worthless without a record of what was discussed and decided. Some strategies for taking notes include: using standing meeting notes with the most recent meeting notes at the top of the document; embedding a link to the agenda/notes in the calendar event and the email reminder; always ending with a review of action items; and circulating a copy of the notes after the meeting.

Set expectations and hold people accountable, both during the meeting and over time. As the facilitator, be willing to "play the heavy" if people don't follow through. As a group, decide in advance how to respond if people don't fulfill their obligations. Ask people to be realistic about their ability to follow through. Avoid the pitfall of just doing the work for people who don't follow through. Invite people to step back if they can't participate. End each meeting with a recap of assignments and to-dos, and send emails after the meeting to

remind people of their tasks with a link to the notes.

Exercise 3. Divide the class into groups of 4-5 people and provide each participant with a 5 x 8 notecard or half sheet of paper. Instruct each person to write down a situation (real or imagined) in which a meeting went off track, using one side of the page only. Option 1 is to have each person read their scenario aloud and ask the members of their group to brainstorm solutions and share with the class. Option 2 is to have each person pass the page to another member of the small group and ask them to write their solutions on the back of the page. Do at least two rounds. Share and discuss in small groups, then re-convene in full group and ask for volunteers to share scenarios and solutions.

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 7.1. Facilitating at the postdoc workshop.

Theme 3: Productive Meeting Structures. A well-planned agenda is the best tool to ensure a productive meeting and your desired results. First, determine the purpose for the meeting. Ask yourself the following questions: Why are we meeting? What are the goals and objectives? What are the deliverables? Next, design an agenda and determine what needs to be discussed, and how to discuss it. Sometimes a free-ranging conversation will be effective, but often more structure is needed in order to ensure that all good ideas are raised and considered. Shoot for your agenda to cover two or three main ideas. Finally, invite the right people to participate in the meeting. Make sure that participants are suited to address the topic or question you are asking. Do they have the knowledge, interest, and authority to positively contribute to the discussion?

Sample Ground Rules

- Be on time, start and end on time
- Cell phones on silent
- What is said here, stays here
- Listen, don't interrupt
- Speak concisely and precisely
- Allow space for others to speak
- Be hard on issues but soft on people
- Differ respectfully
- Don't take yourself too seriously
- Misery is optional: if you don't get it, ask
- Have fun!

Start the meeting with a brief icebreaker. Asking each person in the meeting to briefly introduce themselves will achieve several objectives, including making sure that everyone knows the name and role of the participants, communicating an expectation of active participation, and helping new members feel welcomed and empowered. However, just going around the room to share names and affiliations is usually insufficient. Listeners often tune out, especially if the group is more than 10 people. Coupling introductions with a content question that's relevant to the agenda makes better use of time. Example: "Everyone please share your name, your day job, and one reason you want to help draft this research proposal." If the group is meeting for the first time, meets only sporadically, or is large, consider name tags or table tents. When you introduce yourself, you may also want to include how you see your role as a facilitator, e.g., "My job is to ensure that we get through the agenda, stay on track, and that everyone's voice is heard." This strategy will lend you legitimacy and will make it easier when you have to redirect.

Ask the group to identify several key ground rules or guidelines (see box) that will help them work together and achieve the outcomes. This activity is almost always worth the few minutes it takes. It helps you and the participants to stay friendly and focused, and it enables other people in the group to help you, the facilitator, if someone's behavior is problematic.

Exercise 4. Capitalize on the collective experience in the room to generate a tip sheet with wise practices about how to run a productive meeting. Divide the discussion into three parts: before, during, and after a meeting. You may want to consider different tips for in-person, virtual, and hybrid meetings.

Technique	Best for …	Attendees	Limits
Idea Writing	Getting ideas down on paper and generating immediate feedback	2-4 people per group	Maximum size is flexible. Works with experts.
Nominal Group Technique	Almost any topic. This efficient, structured approach requires little preparation.	5-25, after which break into subgroups.	Maximum of ~150, even with subgroups. Works with experts or laypeople.
Storyboarding	Simpler questions, group warm-ups, or projects that will need to be broken into subcommittees or categories.	3-5, after which break into subgroups.	Maximum of ~30, even with subgroups. Expertise may not be required.
Workshop Method	Complex planning processes or public policy deliberations. Requires more preparation in order to test the discussion question.	15-25, after which break into subgroups.	Maximum of ~100, even with subgroups. Preferably experts or knowledgeable stakeholders.

Table 7.1. Facilitation techniques.

Theme 4: Techniques to Generate and Prioritize Ideas. This theme details four different facilitation techniques: Idea Writing, Nominal Group Technique, Storyboarding, and the Workshop Method. These can each be used for structured brainstorming, and two of them can also help a group to divide up assignments. See Table 7.1 for a quick comparison of the four methods. Detailed instructions for applying each technique are contained in appendixes 7.1 - 7.4.

In Idea Writing, each person writes a challenge, hypothesis, objective, or problem, and proposes a solution. Each individual then passes the form to another person for feedback, and this process is repeated as time allows. This approach is useful for getting ideas down on paper and generating immediate feedback in a short amount of time. It can be used to promote contemplation and quiet writing time, which is useful if a few people are monopolizing the conversation.

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 7.1. A storyboarding exercise at the Postdoc Workshop.

Nominal Group Technique is a simple method for generating a lot of ideas and narrowing them down to key ones. The facilitator poses a foundational question, and has each participant share their answer, with a notetaker capturing a short phrase for each idea on a flipchart, white board, or projected computer screen. Combine similar ideas along the way. Once all the major ideas are shared, use a multi-voting approach to identify priorities.

Storyboarding provides an easy way to generate ideas and organize them into themes or categories. Ask the group the key question and ask participants to write down as many responses to the question as they can think of, one response for each post-it note. After about five minutes, ask one of the participants for one of their items. Read off the item and ask whether any of the other people have a similar item. Cluster similar responses together on the flip chart or wall. Name the clusters to create themes to organize future work.

The Workshop Method can be used to help groups of up to 100 people to generate and develop ideas. It also builds mutual understanding and consensus across the group, helping them select among a range of ideas. Divide participants into groups of 15-25 people, then pose a central question. Then conduct discussion in rounds, with each participant writing the answers to a central question on very large post-its or cards, one idea per card. Subgroups review each other's ideas and collectively agree on the 5-7 clearest ideas to share with the full group. The full group then discusses, combines and refines ideas, clustering similar ones as is appropriate.

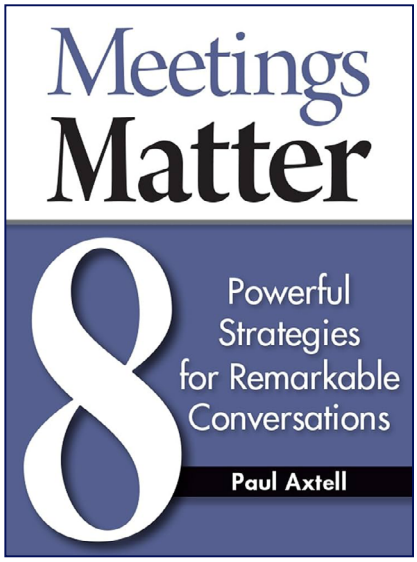
Exercise 5. Lead participants in considering which facilitation techniques work best for hypothetical situations. Examples include:

- A kick-off meeting for an ad hoc committee tasked with developing a new course.
- An organizational meeting for a coalition of postdocs advocating changes to university benefits.
- A gathering to apply for a grant to pursue interdisciplinary research on a topic like advanced manufacturing or artificial intelligence.
- A grant-funded series of community meetings to address a local environmental problem.
- A meeting of researchers seeking to collaborate on watershed management to mitigate wildfire risks.
- A five-year departmental strategic planning process.

Exercise 6. Choose one (or more) of the four facilitation techniques detailed in appendixes 7.1 - 7.4 and practice with the group, potentially applying it to one of the scenarios in Exercise 5. Ahead of time, quietly ask a member of the group to act as a difficult participant (e.g., talking too much, off-topic, showing disdain for the process) and demonstrate strategies for managing the situation. Afterward, discuss where the method was successfully implemented and where it could have been improved.

Additional Resources

Books and Articles



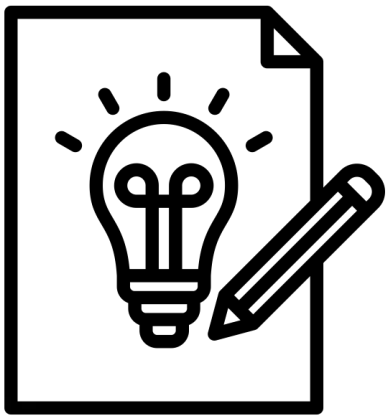
1. Meetings Matter: Eight powerful strategies for remarkable conversations, by Paul Axtell, 2015.
2. The Art of Facilitation: The essentials for leading great meetings and creating group synergy, by Dale Hunter, 2012.
3. Group Techniques for Idea Building, by C.M. Moore, 1994.
4. The Art of Gathering: How we meet and why it matters, by Priya Parker, 2020.
5. The Art of Powerful Questions: Catalyzing insight, innovation, and action, by Eric E. Vogt, Juanita Brown and David Isaacs, 2003.
6. Ask Powerful Questions: Create conversations that matter, by Will Wise, 2017.
7. The Surprising Science of Meetings, by Steven Rogelberg, 2019.

Online Resources

7. Facilitation tools from Liberating Structures
8. Facilitation tools from Technology of Participation
9. Conversation tools from The World Café
10. Facilitation guide from the New Mexico EPSCoR Early Career Workshop

Appendix 7.1 Idea Writing

Idea Writing is a technique to initiate and develop ideas in a small group of two to four people. Each person writes a challenge, hypothesis, objective or problem and proposes a solution. After the initial ideas are generated, the form is passed to another member of the group for feedback, and repeated as time allows. Since many other facilitation approaches involve significant conversation and discussion, this approach can be used to promote contemplation and quiet writing time, which is especially useful if there are a few people who are monopolizing the conversation.



by Eko Purnomo from Noun Project

See the next page for a sample of an Idea Writing form. Each attendee should be given three to five minutes to fill out the left side of the form, including describing a challenge, hypothesis, objective or problem that they propose to address, and proposing a solution. After the left side is complete, the sheet is passed to another member of the group who reviews and writes down constructive comments on the right side (e.g., "I liked this part of your proposed solution, but wonder if you might also consider adding _____.", "I did not understand what you meant by _____; can you clarify?"). As time allows, every person in the small group reviews each of the forms completed by the other members of the group. The form is then returned to the original author to develop a more refined challenge and solution statement in the lower box, based on the feedback they received. The technique concludes with a small group discussion of the refined ideas.

This approach to Idea Writing was modified by W. Michener, based on approaches developed and used in facilitation training provided by Carl Moore as part of the New Mexico EPSCoR postdoctoral training program. It is also based on approaches included in the W.K. Kellogg Foundation Logic Model Development Guide; see also Idea Writing: Generating practical ideas quickly and efficiently by Gordon Rugg (2013).

Idea Writing Form

Name_____

Jot down an important challenge, hypothesis, objective or problem you would like to address; propose a solution	
Challenge, hypothesis, objective or problem Proposed solution	Reactions, such as likes, dislikes, or suggestions for improvement
Refined challenge, hypothesis, objective or problem	

Appendix 7.2 Nominal Group Technique

Nominal Group Technique (NGT) provides a way to generate ideas and to organize them into a prioritized list. It is extremely useful when the time for a meeting is limited, but it is important that all ideas of a group are heard.

Prepare for the meeting. NGT can be used with small or mid-sized groups, with a maximum size of 25. If your group consists of more people, divide into smaller groups. The room(s) should be set up so that each group has a place to gather. For groups at the larger end of that scale, identify a notetaker. For smaller groups, you can often facilitate and take the notes. Each group will need:

- Paper and pens.
- A way to record and post ideas. This can be a flip chart, white board, a shared google file (if everyone has a computer), or preferably a projected computer screen.
- A way to multi-vote on the top priorities. A low-tech option is office supply dots like the ones in Figure 7.1, plus a flip-chart page to stick them to. The higher-tech option is a free cell phone polling app like Poll Everywhere, Poll For All, Pollie, or Google Forms.

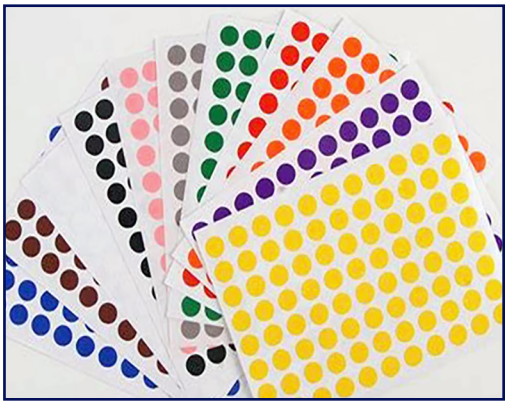


Figure 7.2. Office supply dots.

Keeping in mind what the meeting is expected to accomplish, design a simple question that allows for creative responses, but that is specific enough that everyone's thoughts are channeled in the same direction. Guidelines for crafting powerful questions can be found in the World Café To Go guide.

Brief the group. Outline the steps of the NGT. Your script might read something like:

- *Step 1:* Today our group will consider the following question: What are the most compelling and impactful research questions our department should pose in our next grant proposal?
- *Step 2:* Everyone will work silently and independently for four minutes, to think about the question and jot down your ideas.
- *Step 3:* I will go around the group, inviting each of you to share one of your ideas. We will capture them on the screen. Then we'll hear from you again as needed until we get all your big ideas.
- *Step 4:* We will review the list, confirming none need to be combined or clarified.
- *Step 5:* Lastly, we will use a multi-voting procedure (dots or phone) to identify our top priorities.

Work through the steps. Complete the steps you just described. **Steps 1 and 2** are self-explanatory. Steps 3-5 are described below.

Step 3: Collect ideas. After the group has finished silently writing, invite each person to share one idea, reminding them to be concise. As each idea is shared, briefly capture it on your screen or flipchart and then check it with the person. For example, a group member might say "I'm working on desalination techniques and am testing three different materials for the distillation membrane. So I think the most compelling research question is which of these three materials is most effective?" The notetaker would write down, "Best desal membranes – 3 options.") The facilitator would then state, "Thanks for that idea. Have we captured it correctly on the screen? And does everyone understand the concept?"

Keep collecting ideas, numbering each item in consecutive order. Collect all ideas, if possible, but note that there is a point of diminishing returns if the list gets too long. Experience suggests that a list of 15-20 items will include almost everything of consequence, even for a large group. If a group has 12 or more people, tell members that you will go around the group twice. That will encourage them to offer their best items first.

Step 4: Combine or clarify ideas. Once all of the ideas have been collected, ask if any need to be combined or clarified. Avoid compressing all the ideas into, say, three overly broad categories. But do take care to combine any that are practically alike. If you are now ready to prioritize the list, you can skip Step 5.

Step 5: Hold a multi-vote. Start a flipchart page with the numbers from your list of ideas. If you are using dots, pass out a limited number of dots to each person. If there are 15 ideas give each person three votes; for 15-30 ideas, five votes; and for more 30 ideas, seven votes. Instruct attendees to:

- Take a couple of minutes to decide privately the ideas each person thinks are the highest priority for your group at this time.
- Write the numbers of the ideas on your dots. So, if your three favorites are ideas 4, 10, and 12 on the screen, write 4 on one dot, 10 on the next dot, and 12 on the third.
- Once everyone has determined and noted their favorite ideas, have everyone get up and place their dots by the appropriate items on the flipchart(s).

This simple activity creates visual representation of the group's preferences. The items with the most dots next to them will be the most important items to the group collectively. Use these findings to inform next steps.

The above material was adapted from Group Techniques for Idea Building by Carl M. Moore (1987) and from the Facilitation Guide of the 2022 New Mexico EPSCoR Early Career Workshop.

Appendix 7.3 Storyboarding

Storyboarding (also known as Affinity Diagramming) provides an easy way to generate ideas and arrange them into themes or categories. It gets its name from the Disney Corporation developing "storyboards" for feature-length cartoons.

Step 1: Prepare for the meeting. Storyboarding works best with small groups of 3-6 people. If your group consists of more people, divide into smaller groups. Each group needs a table, part of a wall to post their ideas, a supply of post-it notes (at least 3" x 3") and a water-based marker for each person. If you divided into multiple small groups, you can either facilitate them all at once with overall instructions, or hold a quick training in advance to prepare table-group leaders for each small group.

photo by Brittney Van Der Werff/New Mexico EPSCoR

Figure 7.3. A storyboarding exercise at the Postdoc Workshop.

Step 2: Conduct the meeting. First, Ask the group the key question and ask participants to write down as many responses to the question as they can think of, one response for each post-it note. After about five minutes, ask one of the participants for one of their items. Read off the item and ask whether any of the other people have a similar item. Cluster similar responses together on the flip chart or wall. Read off one item for each person, cluster similar responses as you go, and then instruct them to continue clustering items on their own. Finally, invite the group to name each cluster.

If a number of groups are working on the same item, it is productive to ask everyone to walk around the room and read the categories created by each of the small groups. You can then facilitate a discussion where people report what seem to be common categories that can be found in the work of most of the groups, what surprised them, and what they believe is missing.

Step 3: Discuss next steps. One possibility is to follow up with a "tactical question," such as "What types of hands-on training activities can best prepare our graduate students to teach CHEM 101 in an engaging way?" Another option is a 'big picture' question, such as "Imagine that, in 10 years, our state is recognized as number one in the nation for K-12 STEM education. What changes did we make to our current systems to achieve that excellent outcome?"

Themes that emerge from storyboarding clusters on this latter topic might include curricular changes, mentorships, professional development for teachers, classroom technology, or expanded funding. These five themes can then be formed into subcommittees or working groups, or can serve as the foundation for deeper discussions at a future meeting (perhaps using one of the other techniques).

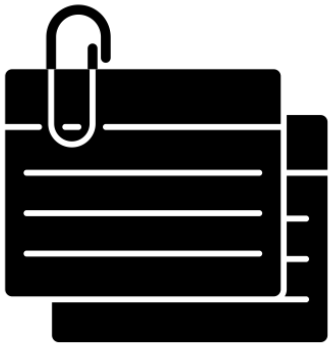
The above material was adapted from the Facilitation Guide of the 2022 New Mexico EPSCoR Early Career Workshop.

Appendix 7.4 The Workshop Method

The Workshop Method can help groups of up to 25 people to generate and develop ideas. It also builds understanding and consensus across the group, helping them to select from among a range of ideas.

Step 1: Prepare for the meeting. Gather very large sticky notes or pre-cut construction paper, approximately 8" x 6"; black markers; and painter's tape (if you are using construction paper instead of sticky notes). Make sure the meeting room has adequate wall space to post the notes and to rearrange them as needed. Use several of the cards to display instructions on how to use the notes; for example, "One idea per card," "Use 3-5 key words," "Write big," etc. Post these notes in a column on the wall space where you will be posting the participants' notes.

Step 2: Conduct the meeting. If your meeting is larger than 25 people, divide into small groups. Explain the topic and goal of the meeting, highlight the question to be addressed and outline the process and the timeline for each part of the meeting. The discussion will proceed in a series of rounds, with the number of rounds depending on the time allotted and the number of participants. You can also adjust the number of ideas to be submitted by both individuals and sub-groups for consideration given the time allowed. The following is an example.



Nesterenko Ruslan from Noun Project

- Round 1: Individuals (approximately 5 minutes). Individuals record 5-6 ideas that answer the question, each idea on a separate card. They then select their three best ideas.
- Round 2: Subgroups of 3-5 (approximately 20-40 minutes). Each sub-group reviews each individual's three ideas and comes to consensus on 5-7 ideas to share with the full group. They should rewrite these ideas as they are probably the result of combining similar ideas or building on ideas. However, the resulting 5-7 ideas should still be expressed succinctly and clearly. At this point you could combine two sub-groups and repeat this step, or proceed to Round 3.
- Round 3: Full group (approximately 45 minutes). Ask the first subgroup to report out and post their 5-7 ideas, one idea at a time. Ask subsequent groups to do the same, but to refrain from posting duplicate ideas. All unique ideas should be posted.
- Round 4: Full group discussion (approximately 30-45 minutes). Lead the full group in a discussion to flesh out, clarify, combine, build on, and advocate for the ideas. This may lead to clustering of ideas that create an integrated idea. At the conclusion of the final round, summarize the key ideas and move onto next steps such as a deeper exploration, prioritization of the ideas, selection of the top idea(s), or action planning for implementation.

Question strategy. Of the methods presented in this module, this technique takes the most time and preparation. It is worth it for complex questions that will require a lot of learning and consensus. We recommend that the facilitator work through the questioning strategy (lead question, follow-ups, etc.), and try it out in advance with a small group. This step is especially valuable if you are planning an event for 50 or more people, or for skeptical participants.

A sample community engagement question might be, "Our university has been asked to lead a water planning initiative in our town and research the outcomes. What are the most pressing water needs in our community?" A sample public policy question might be, "Our coalition is developing a legislative policy platform to mitigate impacts of coastal erosion in our state. Based on your area of expertise, what are your greatest concerns about our coastline's future?"

This method was initially created by the Institute of Cultural Affairs. The above is a variation on this method, developed by the policy facilitation team of the 2022 New Mexico EPSCoR Early Career Workshop.

8 Integrating Diversity, Equity and Inclusion

Introduction

The field of Diversity, Equity, and Inclusion (DEI) is vast, complicated, and constantly evolving. This module focuses on characterizing DEI, including a review and discussion of prior research. It will introduce postdocs to DEI statements and DEI-related funding opportunities, as well as to DEI programs at the National Institutes of Health and the National Science Foundation.

Themes and Exercises

Learning Objectives

1. Characterize Diversity, Equity and Inclusion (DEI)
2. Develop a DEI statement, and learn about critical analysis of the statements
3. Discuss a sample rubric for evaluating DEI statements
4. Learn about NIH UNITE and NSF Broader Impacts programs and opportunities

Theme 1: Characterizing DEI. *Diversity* refers to representation of people's identities and experiences. *Equity* focuses on investing attention and resources to improve conditions of marginalized groups, including providing fair treatment and access to opportunity and advancement. *Inclusion* consists of intentional and proactive efforts to ensure that everyone has equitable access to opportunities and resources; is empowered to participate equally; and offers and is offered respect. In addition, *Justice* is the right to be treated and the responsibility to treat others with fairness and equity in order to challenge and rectify prejudices and biases.

Exercise 1. Have the participants share their experiences (or lack of experiences) with diversity, equity, and inclusion-related issues and what DEI means to them.

Theme 2: DEI Statements. In recent years DEI statements, also referred to as Diversity statements, have been added to the list of application requirements for faculty positions. DEI statements are 1-2 page narratives that convey personal and professional experience with DEI, and that demonstrate a commitment to advancing it. Crafting an authentic and effective DEI statement requires personal reflection on experiences and goals, as well as study into prior DEI research and the DEI mission and statements of the institution to which one is applying.

A recent study by Bombaci and Pejchar, "Advancing Equity in Faculty Hiring with Diversity Statements," found that the statements have both advantages and disadvantages. The authors noted that DEI statements provide the following advantages: they demonstrate a candidate's genuine interest, awareness, and commitment to DEI; demonstrate how a candidate will interact with colleagues and students; signal institutional commitment to DEI; engender in the candidate a commitment to DEI; raise awareness of the need for DEI work; and broaden qualifications to include and recognize DEI work. On the other hand, the authors also noted that DEI statements: do not ensure a candidate's sincerity or future commitment; should not be the only method to evaluate a candidate's commitment to DEI; are less useful if an institution lacks DEI core values and is unable to evaluate candidates effectively; and put unfair burden on non-minoritized individuals or those that do not prioritize DEI.

DEI statements are evaluated with tools such as rubrics. Faculty candidates are evaluated on their knowledge about DEI, track record in advancing DEI, and their plans for advancing DEI. Rubrics are a valuable tool for evaluating DEI statements, and should be tailored by institutions and search committees for individual faculty positions. Appendix 8.1 (below) consists of a sample rubric for evaluating DEI statements. Please note that the sample rubric should not be used as a comprehensive approach for evaluating DEI statements. Institutions and search committees should craft rubrics for faculty positions.

Exercise 2. Have the participants develop an abbreviated DEI statement. Share the following questions with participants to stimulate their writing: What does DEI mean to you? Why is DEI important to teaching, research, and service? How have you contributed to DEI? What are your plans for advancing DEI? Have the participants share their statements out loud upon completion of the writing exercise.

Exercise 3. Have participants review Bombaci and Pejchar's 2022 article "Advancing Equity in Faculty Hiring With Diversity Statements." Facilitate a discussion of the article, in particular the piece's conclusions about the advantages and disadvantages of DEI statements.

Theme 3: NIH and NSF Requirements and Opportunities. Many federal, state, and non-profit organizations have DEI programs. Two of the programs most significant to postdocs are administered by the National Institutes of Health and the National Science Foundation, both of which also offer numerous funding opportunities related to DEI.

The NIH UNITE initiative was founded in 2021 to identify and address structural racism that may exist in biomedical and behavioral science. The program has four focus areas: elevating research into health disparities and minority health; promoting equity in the NIH-supported biomedical research ecosystem; promoting equity in the internal NIH workforce; and improving the accuracy and transparency of racial and ethnic equity data.

The National Science Foundation and NSF EPSCoR (Established Program to Stimulate Competitive Research) have a demonstrated commitment to DEI, broadening participation, and the broader impacts resulting from their programs and initiatives. Broader impacts focus on inclusion, improving STEM education, public engagement, societal well-being, STEM workforce, building partnerships, improving national security, increasing economic competitiveness, and improving infrastructure. NSF requires broader impact statements as part of grant proposal requirements and holds funded projects accountable for the broader impacts described in the proposal. NSF EPSCoR includes DEI-related language in their goals and released a report in 2022 including eight recommendations and 19 suggestions that align with broader impact principles. One major NSF DEI funding opportunity is GRANTED (Growing Research Access for Nationally Transformative Equity and Diversity), which focuses on addressing systemic barriers by improving research support and service capacity at emerging research institutions.

Exercise 4. Have participants identify opportunities for DEI-related funding, including listings from the NIH and NSF.

Additional Resources

Articles

1. Breaking Down Diversity Statements, by Colleen Flaherty, 2018.
2. The Effective Diversity Statement, by Tanya Golash-Boza, 2016.
3. Eight Practical, Sustainable Steps to a Diverse Faculty, by Gracie Lawson-Borders and David Perlmutter, 2020.

Online Resources

4. NSF 101: Five Tips for Your Broader Impacts Statement
5. Perspectives on Broader Impacts from the NSF

Appendix 8.1 Sample Rubric for Evaluating DEI Statements

DEI Knowledge	
1-2	• Candidate expresses little knowledge of, or experience with, dimensions of diversity that result from different identities. Defines diversity in terms of different areas of study or different nationalities, but doesn't discuss gender, ethnicity or race. • Candidate expresses little understanding of demographic data related to diversity in higher education or in their discipline. May use vague statements such as "the field of engineering definitely needs more women." • Candidate seems uncomfortable discussing diversity-related issues, lacks awareness or understanding of the personal challenges that underrepresented individuals face in academia, or does not feel any personal responsibility for helping to eliminate barriers.
3	• Candidate may express little understanding of demographic data related to diversity and have less experience and interest in dimensions of diversity. However, they may show an understanding of challenges faced by underrepresented individuals and the need to eliminate barriers, and be comfortable discussing diversity-related issues.
4-5	• Candidate exhibits knowledge of, experience with, and interest in dimensions of diversity that result from different identities, such as ethnic, socioeconomic, racial, gender, sexual orientation, disability, and cultural differences. This understanding can stem from personal experiences as well as an investment in learning about the experiences of those with identities different from their own. • Candidate is aware of demographic data related to diversity in higher education. • Candidate is comfortable discussing the underrepresentation of many groups and the consequences of this fact for higher education and/or for their discipline. Candidate is comfortable discussing diversity-related issues (including distinctions and connections between diversity, equity, and inclusion) in writing, in a job talk session, and in one-on-one meetings with students, staff, and faculty. • Candidate will work to identify and eliminate barriers to full and equitable participation and advancement.
Track Record in Advancing DEI	
1-2	• Candidate has participated in two or fewer DEI activities and only cites activities at which faculty attendance is expected. Descriptions of activities are brief, vague, or only include peripheral involvement, or activities described are purely informational in nature (for example, attending a workshop at a conference).
3	• Candidate may have participated extensively in a single activity or may have limited participation in numerous activities, or participation in only one area, such as research to the exclusion of teaching and service. • Candidate may mention specific strategies used for effective mentoring, or awareness of the barriers underrepresented students face and how to incorporate the ideas into their mentoring.
4-5	• Candidate describes multiple activities in depth with detailed information about both their role in the activities and the outcomes. Activities may span research, teaching and service, and could include applying their research skills or expertise to investigating DEI issues. • Candidate displays a consistent track record that spans multiple years. • Candidate may have organized or spoken at workshops or other events aimed at increasing others' understanding of DEI. • Candidate may have served as a leader in a student or professional organization that supports underrepresented individuals.
Plans to Advance DEI	
1-2	• Vague or no statements about DEI activities if hired. May even state that doing so is the responsibility of someone else. Candidates describe only activities that are already expected of University faculty.
3	• Candidate mentions plans or ideas insufficient for their career stage. Plans or ideas lack detail or clarity.
4-5	• Candidate presents clear and detailed ideas for what existing programs they would involve themselves with, and what new ideas they have for advancing equity and inclusion at the university and within their field. • Level of proposed involvement commensurate with career level (for example, a new assistant professor may plan to undertake one major activity within the department over the first couple of years, conduct outreach to hire a diverse group of students to work in their lab, seek to mentor several underrepresented students, and co-chair a subcommittee for a national conference. A new tenured faculty would be expected to have more departmental, campus-wide, and national impact, including leadership).

Developed by Oliver Myers.

Module Set C: Project Management

Module Authors

9 Proposal Development

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10 Managing Research Projects

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11 Communicating Science to the Public

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9 Proposal Development

Introduction

This module focuses on some of the most commonly encountered challenges in acquiring funding to address specific challenges in research, education, and other fields. Its themes relate to developing individual research plans, identifying potential funders and collaborators, recognizing and crafting successful proposals, and using tools like SMART objectives and logic models. It serves as an introduction to proposal writing that can be supplemented by in-depth courses provided by colleges, universities and professional organizations (such as these by the Nature journal) that include sections on grant proposals.

Learning Objectives

1. Develop an individual research plan
2. Identify funding sources and potential collaborators
3. Identify characteristics of successful proposals
4. Understand the concepts of idea writing, SMART objectives, and the Kellogg Logic Model

Themes

Theme 1: Develop an Individual Research Plan. A research plan represents an initial effort to brainstorm and document potential research goals, why they are important, and what steps might be taken to accomplish these goals. Participants will develop an abbreviated research plan that can be expanded and modified over time to reflect their evolving perspective.

Exercise 1. Have participants develop an abbreviated individual research plan. Ask them to take 30 minutes and reflect upon their research goal(s), why they are important, and what steps can be taken to achieve them. Ideally, participants will each identify at least one goal, provide 2-3 reasons why research in that area is impactful, and propose one or more steps that can be taken to begin achieving that goal.

Theme 2: Identify Funding Sources and Collaborators. Participants will learn to identify potential sponsors that may support research or education projects focused on a particular theme, as well as foundations that fund activities in particular states or regions of the country. They will assess the expertise needed for their research proposal to determine if it exists in-house or is needed from elsewhere.

Category	Questions
Theme	What research or education themes are encouraged in the RFP?
Scope	Does the RFP specify the potential scope of a project (e.g., size, length, number of personnel engaged, location)?
Alignment with interests	Do the themes and scope align well with my particular interests?
Alignment with knowledge and skills	Do I have the requisite knowledge and expertise to perform research in this area?
Filling in gaps	What are the gaps with respect to alignment with my interests, knowledge and skills and those of potential collaborators? How can they best be filled?
Previously funded research	Has the funder previously supported research or education projects that align with my topic of interest?
Communication to gain additional information	What additional information should I seek from my institutional research office, my college or department, and/or the funder to decide whether or not to pursue this opportunity?

Table 10.1. Criteria for evaluating and prioritizing funding opportunities.

Exercise 2. Have participants visit the grants.gov website and search for federal funding sources that support research or education in particular subject areas. They can also visit guidestar.org and search for foundations that fund research and education programs in specific states or regions, in addition to nationwide. This exercise can be expanded by having participants address the questions posed in Table 10.1 (above) and use the results to identify Requests for Proposals (RFPs) that align with their interests, knowledge

and skills.

Exercise 3. Have participants use a skills matrix to identify collaborator needs for a potential proposal. In Column 1, list the skills or expertise needed. Note in Column 2 whether a Co-PI is needed. Column 3 notes if a sub-contract or service is needed. Column 4 indicates if tasks could be accomplished by a graduate or undergraduate student.

Bourne and Chalupa's 10 Rules

1. Be novel, but not too novel
2. Include the appropriate background and preliminary data as required
3. Find the appropriate funding mechanism, read the associated request for applications very carefully, and respond specifically to the request
4. Follow the guidelines for submission very carefully and comply
5. Obey the three C's - concise, clear, and complete
6. Remember, reviewers are people, too
7. Timing and internal review are important
8. Know your grant administrator at the institution funding your grant
9. Become a grant reviewer early in your career
10. Accept rejection and deal with it appropriately

Theme 3: Identify Characteristics of Successful Proposals. Participants will brainstorm, discuss and, potentially, rank the characteristics of successful proposals. They will also review and discuss the content of P.E. Bourne and L.M. Chalupa's invaluable 2006 article 10 Simple Rules for Getting Grants (see box), and use the discussion as a springboard to establishing a tentative timeline for a hypothetical or real proposal submission.

Exercise 4. Have participants brainstorm the characteristics of successful proposals. Ask each participant to jot down 3-5 characteristics, then have each participant read one new characteristic while the instructor develops an overall list.

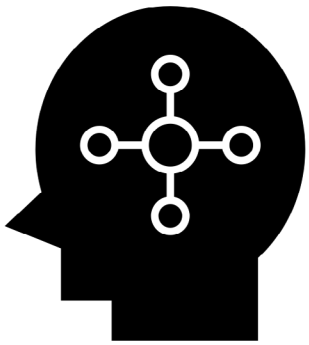
Exercise 5. Have participants read 10 Simple Rules for Getting Grants and discuss the article with them. Then have them develop a timeline for a hypothetical program, either fictional or based on a real solicitation. Use Table 10.2 (below) to identify tasks to be completed, the dates on which tasks need to be completed, internal and institutional deadlines, and the responsible party or parties to complete the task. Participants can then assess the feasibility of the proposed timelines.

Theme 4: Tools for Proposal Development. Participants will be introduced to the concepts of idea writing, SMART objectives, and the Kellogg Logic Model as mechanisms for crafting successful proposals. Idea writing is a tool that can be used to develop compelling objectives and to propose solutions, and is described in detail in the Facilitation module. However, researchers must not only generate compelling ideas, they must

Due Date	Activity	Responsible parties
	Scientific meetings with team or leads	
	Rough draft and draft budget(s) due	
	First draft of narrative and budget justification due	
	Edit drafts, update budgets and gather project elements (letters of collaborations, letters, budget tables, justifications, etc.) for external review	
	Complete draft narrative and send out for external review	
	Senior Personnel proposal documents due	
	Upload all proposal documents to internal systems and federal agencies	
	Finalize proposal based on reviews, and prepare for submission	
	Submit final proposal to institutional research office for review	
	Submit to funding agency	

Table 10.2. Proposal development timeline sample template.

also convince reviewers that their goals can actually be reached if the work is funded. One way reviewers gauge the feasibility of proposals is by assessing whether the objectives and activities are SMART: Specific, Measurable, Attainable or Achievable, Relevant, and Time-Bound.



Srinivas Agra from Noun Project

Researchers can further flesh out SMART objectives through application of the Kellogg Logic Model, which "facilitate(s) thinking, planning, and communications about program objectives and actual accomplishments." After documenting the objective to be reached, proposal writers can employ logic models to complete four steps: 1) describe what activities would be performed to reach the objective; 2) identify specific outputs of the activities, such as number of students trained, resulting publications, workshops held, etc.; 3) list short-term outcomes—i.e., the tangible benefits that would be expected to emerge during the grant period; and 4) identify anticipated long-term impacts beyond the life of the funded project.

Oftentimes, proposal writers benefit from internal or external assessments of their proposals, including whether the proposed activities, outputs, outcomes, and impacts related in steps 1-4 are sufficiently compelling to resonate with reviewers. If they are not deemed sufficiently compelling, then it is often beneficial to move on to another idea. If the reviewer, on the other hand, does find the draft proposal compelling, then step 5 is to itemize the resources needed to perform the activities listed in step 1. See Appendix 10.1 for an example of a logic model.

Exercise 6. Have participants use idea writing (see Facilitation module) as a mechanism to derive SMART objectives for a proposal. Seek volunteers to then explain how their objective and solution statements benefited from the constructive feedback they received from fellow attendees.

Exercise 7. Have participants take one or more SMART objectives developed as part of Exercise 3 and further develop them using the Kellogg Logic Model template (Appendix 10.2). Lead participants in reviewing and discussing logic models completed as part of this exercise, seeking constructive suggestions for how to make compelling models. Sample questions could include, a) Is the objective or problem clear, concise, and compelling?; b) Are all necessary resources included?; c) Are the activities reasonable and is anything missing?; d) Can the outputs be easily measured and is anything missing?; e) Are the outcomes reasonable and compelling, and is anything missing?; and f) Will the impacts resonate with the target audience?

Exercise 8. Ask participants to convert their logic model into a mini-proposal that can then be shared with and reviewed by other participants. Or, ask participants to review and comment on the strengths and weaknesses of one or more successfully funded proposals.

Additional Resources

Books and Articles

1. Writing a Research Plan, by Jim Austin, 2002.
2. The Academic Job Search Handbook, by Julia Vick, Jennifer Furlong and Rosanne Lurie, 2016.
3. How to Construct a Compelling Research Statement, by Darren White, 2020.

Online Resources

4. Writing a Research Statement from Carnegie Mellon University
5. Research Statement information from Cornell University
6. Writing the Research Plan for Your Academic Job Application, by Jeff Gilmore of the American Chemical Society
7. Research Statements for Faculty Job Applications from the University of Pennsylvania

Appendix 9.1 Example of a Kellogg Logic Model

Problem: Postdocs lack important communication, collaboration, and other skills
Solution: Create an annual weeklong, training program to provide postdocs with necessary skills

Resources	Activities	Outputs	Short-Term Outcomes	Impact
In order to address our problem we will need:	*In order to address our problem we will:*	*We expect these activities to produce the following deliverables:*	*We expect these activities to effect the following changes in 3-5 years:*	*We expect these activities to effect the following changes in 6-10 years:*
Support for 2-3 steering committee planning workshops Travel support to interview postdoc focus group(s) Engagement of evaluator to develop evaluation instrument Fund to create ad and marketing materials Instructor stipends Funds for lodging, meals and workshop attendance, including both instructors and postdocs One month of salary per year for faculty coordinator	Create steering committee Interview postdocs to determine needs and desires Propose a weeklong program and vet with postdocs; revise and iterate Identify potential instructors and course materials Develop, review and revise curriculum Develop pre- and post- evaluation instrument Develop ad and marketing Schedule workshop and organize meals, lodging and logistics Conduct the workshop Conduct surveys and interpret results Revise for the following year	Steering committee Number of postdocs in focus group(s) Curriculum Evaluation instrument Marketing materials Workshop Number of postdocs trained Evaluation report	3-5 cohorts of trained postdocs Increased self-reported skills assessment Fully attended workshops, largely due to word-of-mouth Program viewed as a success and adopted by one or more other states, universities, etc.	Additional postdoc training viewed as essential by universities within state and is institutionalized Curriculum is adopted and refined by multiple institutions nationally

Appendix 9.2 Kellogg Logic Model Template

Please note the numbering of the columns in this template: once the problem and solution statements are defined, it is often best to fill out columns 1-4 first. Then only fill out column 5 if the activities, outputs, outcomes and impacts are deemed sufficiently compelling to warrant the effort necessary to price out the project.

Problem:_____

Solution:_____

5. Resources	1. Activities	2. Outputs	3. Short-Term Outcomes	4. Impact
In order to address our problem we will need:	*In order to address our problem we will:*	*We expect these activities to produce the following deliverables:*	*We expect these activities to effect the following changes in 3-5 years:*	*We expect these activities to effect the following changes in 6-10 years:*

10 Managing Research Projects

Introduction

This module provides a conceptual framework and a variety of tips and tools necessary to manage research projects up to about $5 million in size. It builds on the Proposal Writing module, in particular its discussion of the Kellogg Logic Model for proposal design. For a more in-depth discussion of research project management consider the book Project Management for the Unofficial Project Manager by Kory Kogon, Suzette Blakemore and James Wood.

Learning Objectives

1. Develop a project schedule and budget
2. Track project progress and assess and mitigate risks to the project
3. Evaluate project success
4. Craft a communication plan

Themes and Exercises

Theme 1: Scheduling and Budgeting. Participants will learn how to develop a project's work breakdown structure (WBS) and accompanying schedule. The WBS for a project is a logical grouping of all deliverable- or output-oriented tasks or elements that underpin the project. For example, the WBS for a one-day workshop might include: 1) identifying the theme and desired outputs and outcomes; 2) identifying and contacting desired participants; 3) securing a venue; 4) organizing catering; and 5) selecting the date and time. An organizer can arrange tasks or elements by creating a simple list such as the one above, arranging sticky notes, or adopting more sophisticated approaches such as Mind Maps. Next steps might include sequencing tasks; estimating their duration, perhaps with the Program Evaluation and Review Technique (page 105 of Kogon et al.); and identifying key project milestones.

PROJECT SCHEDULE | **GANTT CHART**

No.	Deliverables/Components/ Activities/Tasks	Predecessor	Work Hours	Duration	Start Date	End Date	Responsible Party	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
1	**Draft Workshop Plan**														
1.1															
1.2															
--															
2	**Secure Funding**														
2.1	Identify potential funder	1	1 hr				Bill								
2.2	Read workshop RFP	2.1	1 hr				Bill								
2.3	Create requirements matrix	2.1	2.5 hr				Bill								
2.4	Identify proposal writing team	2.3	3 hr				Bill								
2.5	Outline proposal by section	2.4	6 hr				Bill, Ana, Pips, Arun								
2.6	Assign writing tasks	2.4	1 hr				Bill, Ana, Pips, Arun								
2.7	Write proposal	2.6	80 hr				Bill, Ana, Pips, Arun								
2.8	Prepare CVs and C&Ps	2.3	6 hr				Ana								
2.9	Incorporate budget	2.4	10 hr				Arun								
2.10	Review and revise	2.7	20 hr				Bill, Pips								
2.11	Get SPO approval	2.10	1 hr				Bill								
2.12	Submit proposal to research.gov	2.11	2 hr				Ana								
--															
3	**Food and Lodging Contracts**														
3.1															
--															
4	**Hold Workshop**														
4.1															
--															
5	**Disseminate Results**														

Figure 11.1. Example of a draft project schedule created using a spreadsheet program. ("Predecessors" are tasks that need to be completed before a specific task can be undertaken.)

Budgeting is another critical element of project management. Participants will learn the three different budgeting methods: Top-down, in which the budget is set by the principal investigator, steering committee,

or funder, who often allocates a percentage of the total budget to each task; bottom-up, in which each task is priced out in detail; and a hybrid of top-down and bottom-up, which is by far the most common approach.

Exercise 1. Lead participants in creating a schedule for a simple project, such as a one-day workshop. Use mind maps, post-it notes, a spreadsheet program (see Figure 11.1 above), or simple lists to brainstorm deliverables and to identify project tasks or components. Ask participants to then group and sequence the various tasks into major activities such as proposal writing, implementing the project, and assessing its outcomes and impact. If time allows, introduce the Program Evaluation and Review Technique which can be used to estimate the duration of each task, and use the technique with a subset of the tasks identified by the group.

Exercise 2. Have participants review and critique one or more project budgets. Ideally this would include samples of both well-crafted and problematic budgets. A "bad" budget, for example, might not include key budget items or wildly inflate the cost of certain items.

Theme 2: Tracking and Risk Assessment. Participants will learn how to track progress with Gantt charts (see Figure 11.2). Other key lessons are the need for frequent communication among participants to track progress, and how to avoid "scope creep," whereby participants tend to continually add new goals and tasks to a project, increasing the risk of failure.

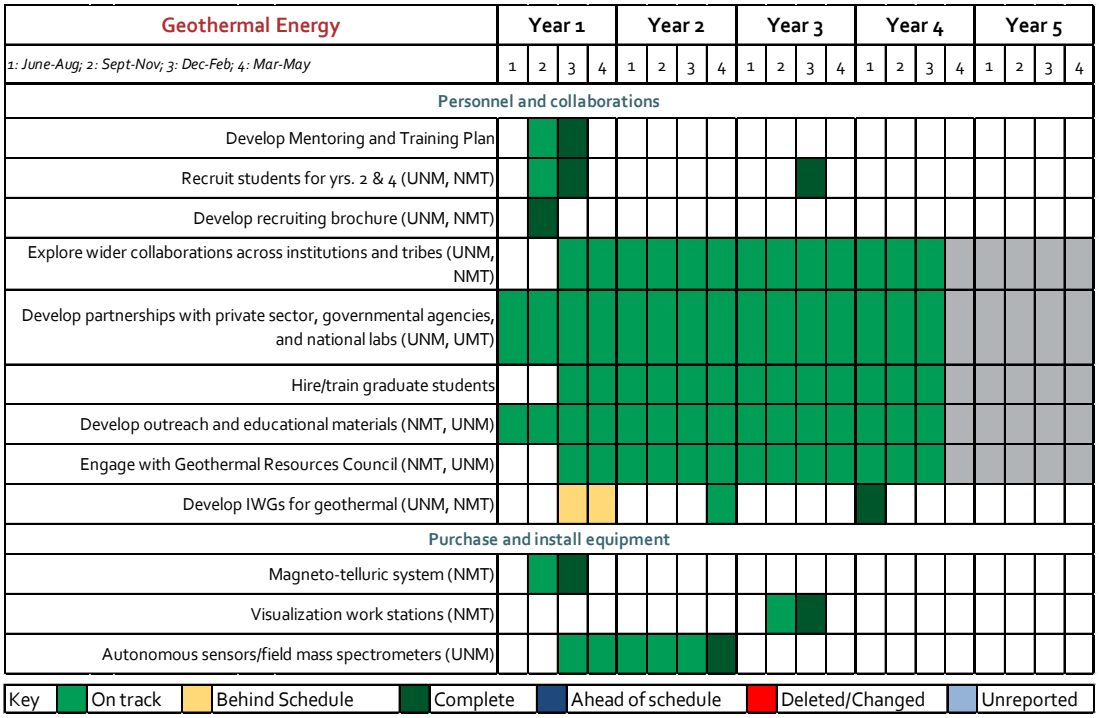


Figure 11.2 Sample Gantt chart.

Project success can be affected by any number of developments that can cause delays, impact the budget, and potentially necessitate changes in scope. Projects are more likely to succeed if leads and participants craft a risk management plan, which identifies likely risks, assesses the potential severity of their impacts, and indicates ways the risks can be mitigated. One method for building such a plan is to rate risks on 1-to-5 or 1-to-3 scales for both their probability of occurring, and the severity of their impact. Multiplying these scores yields a total score for overall risk. Figure 11.3 (below) represents a 5x5 risk matrix; in this case, any risk that scores 8 points or more warrants developing a strategy to transfer, accept, mitigate or eliminate the risk, including assigning responsibility for the mitigation.

Exercise 3. Have participants develop a Gantt chart, either on paper or in a spreadsheet program, that is based on the project schedule and milestones developed in Exercise 1.

Exercise 4. Have participants, individually or in small groups, build a risk assessment matrix by brainstorming risks and scoring them based upon their estimated likelihood and impact. Then ask the learners to develop a mitigation plan for the top three risks. The plan should address how to prevent the risk from occurring, actions to take to respond to the risk if it comes to fruition, and the parties responsible for preventing and responding to the risk.

Likelihood \ Severity	1	2	3	4	5
1	Low 1	Low 2	Low 3	Medium 4	Medium 5
2	Low 2	Medium 4	Medium 6	High 8	High 10
3	Low 3	Medium 6	High 9	High 12	Extreme 15
4	Medium 4	High 8	High 12	High 16	Extreme 20
5	Medium 5	High 10	Extreme 15	Extreme 20	Extreme 25

Figure 11.3. 5x5 risk matrix.

Theme 3: Evaluation. Attendees will learn about Key Performance Indicators, metrics to assess progress toward project goals. This theme also encompasses basic rules of thumb for project evaluation: 1) Keep it simple and straightforward; 2) incorporate Key Performance Indicators; 3) Determine the kinds of data you need and design methods to capture it; 4) Avoid metrics or indicators that are difficult to capture; 5) Identify someone to capture data; and 6) Contract or otherwise arrange for assistance if needed. The theme will also reference the Kellogg Logic Model as a method for evaluating resources, activities, outputs, outcomes and impacts. It will introduce the "stoplight analysis" technique, in which progress with respect to performance indicators is color-coded so that on-time, slightly delayed and heavily delayed elements are respectively displayed in green, yellow and red (see Figure 11.4).

Exercise 5. Have participants use the Kellogg Logic Model to identify one or more evaluation measures for the sample project from exercises 1 and 3.

Theme 4: Communication. This theme entails drafting a communications plan that identifies key stakeholders, individual(s) responsible for communicating with each stakeholder, and specifics such as the preferred type, mode, and frequency of communications. Project stakeholders are often broken into three categories: 1) internal stakeholders, including project leaders, participants, and individuals such as subcontractors and external evaluators; 2) external stakeholders with a role in the project, such as funders and university administrators; and 3) external stakeholders impacted by the project, such as educators, science organizations and the public. A communications plan should contain strategies for sharing information with all three groups. For instance, in regards to internal stakeholders, a plan should incorporate a preferred frequency, timing and format for meetings and other types of communication. The plan should address the content, frequency and venue for reporting to funders and administrators, and methods for disseminating results to the public and other audiences, such as publications and conference presentations, social media, a website, and newsletters.

Component	Spending	Publications	Proposals	Presentations	Data Upload
Bioalgal	79%	10/8	9/8	35/18	NMSU
Solar	77%	3/2	5/7	9/7	NMT
Osmotic	74%	0/2	2/4	11/3	NMT
Geothermal	80%	2/2	5/5	23/5	UNM
Uranium	84%	2/2	1/1	15/4	NMT
Natural Sci	58%	0/2	1/2	10/5	NMSU
Cyber	76%	2/2	2/2	9/3	N/A

Figure 11.4. Example of "stoplight analysis" technique.

Exercise 6. Ask participants to identify 3 to 5 stakeholders for the aforementioned sample project and describe how and how often the project will communicate with them. Attendees should identify several key milestones, outcomes, or activities that will be of most interest and relevance to stakeholders. They should also lay out plans for project meetings, including frequency, specific processes and platforms, and methods for keeping and sharing records.

Additional Resources

Books and Articles

1. The Fast Forward MBA in Project Management, by Eric Verzuh, 2015.
2. A Guide to the Project Management Body of Knowledge, by the Project Management Institute, 2021.

11 Communicating Science to the Public

Introduction

This module focuses on fundamentals of science communication, and aims to build core skills in a short period of time. It serves as a valuable first step toward more extensive training and advanced study of specific media platforms and in areas of science that pose specific communication challenges.

Themes and Exercises

Theme 1: Connecting with Audiences. Two questions every journalist wants answered in an interview are "why now?" and "who cares?" Scientists need to prepare for both of these questions by having a deeper understanding of their target audience, including understanding their needs and effective ways to engage with them. The so-called "knowledge deficit model," which holds that a lack of knowledge is the reason non-specialists don't trust or engage with science, has been repeatedly refuted in science communication research. What actually matters is trust: people can change their minds based on information from a trusted source. Approaching people with dignity and respect is paramount, as are demeanor, trustworthiness, passion, and enthusiasm.

Learning Objectives

1. Understand a target audience and set appropriate goals for communicating with it
2. Craft and deliver communication appropriate for that audience, grounded in context that builds trust
3. Build basic but effective stories that are accurate and engaging to a target audience
4. Know how to prepare for a media interview

Another key barrier to effective science communication is the use of domain-specific language, otherwise known as jargon. For individuals outside of a particular field, field-specific jargon is alienating and can feel humiliating. Using language that is accessible and aligned with audience needs, interests, and contexts can help bridge gaps between science and society.

Exercise 1. Guide participants through use of the COMPASS Message Box, a downloadable tool and workbook that can be used to design effective science communication. The tool demonstrates to researchers how to parse information into segments designed to build trust in a particular audience. Each participant will select an audience and then work through the five sections in each box, entitled "Issue," "Problems," "So what?," "Benefits," and "Solutions." With practice, postdocs can winnow the content of each section into a few clear sentences that will work for the selected audience.

> The so-called "knowledge deficit model," which holds that a lack of knowledge is the reason non-specialists don't trust or engage with science, has been repeatedly refuted in science communication research.

The Message Box exercise helps impart an important lesson to learners: the difference between ignorance and innocence. Audiences are not ignorant; rather, they are innocent of the jargon, underlying assumptions, history and findings of the science being presented. Raising awareness of this difference will help postdocs to craft clearer and more effective messages.

Exercise 2. Lead participants through a research report created by ScienceCounts. Facilitate a conversation about the data, then ask participants to choose a target audience for a hypothetical interaction. The postdocs then prepare a one-minute elevator pitch to the target audience and practice in pairs using Half-Life Your Message, an exercise adapted from improv theater. This exercise will help postdocs to practice conveying information to a target audience while receiving feedback and support from a partner, and will help deepen understanding of different perspectives on science.

Exercise 3. Show a brief video to the group, such as The Turboencabulator or The Brain, that lightheartedly calls out how alienating and obfuscating science can feel to a non-specialist. Have participants discuss what was funny and effective about the clip, such as choice of language, verbal style, props, and clothing. Then, share a scientific abstract with the group, preferably in an area that is not familiar to everyone in your group. Have the group read through the abstract and identify an individual to try to explain the meaning of the abstract. Have individuals in the group share back their interpretation of this explanation, and continue the exercise until the message at the core of the abstract genuinely lands with the audience. Conclude with a discussion of the specific challenges in translating the abstract from science language to non-specialist messaging.

Image courtesy Alan Alda Center

Figure 11.1. An exercise from a workshop put on by the Alan Alda Center for Communicating Science.

Theme 2: The Nature of Story. We experience our world and make sense of it through story. Using the principles of storytelling to convey information is an impactful way to share science with non-specialists. A scientist needs a beginning, middle and end, engaging characters, context, and tension to keep a story moving forward. Under this theme, participants will develop a basic understanding of how stories are structured and how to create accurate yet compelling narratives that align with their target audiences.

Exercise 4. Have participants complete Exercise 1, then repackage the central ideas in their message box as a story. Instruct them in elements of character, plot, scene, theme, dialogue, sensory detail, and structure, accentuating the fact that each story has a beginning, middle and end. To start, ask participants to select a sequence of events on which to base a story, which may only constitute a small slice of their research. Help them search for details, including recalling moments of hope, frustration or discovery, as well as sights, sounds, smells, colors, textures and other aspects of environmental awareness. Encourage the use of metaphors and strong verbs.

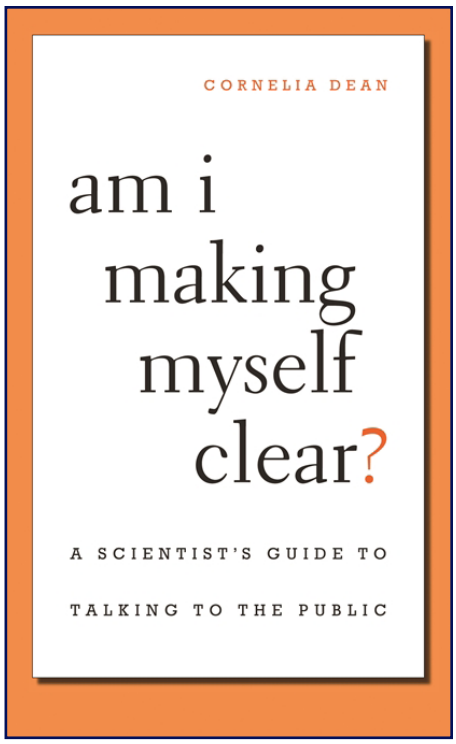
Theme 3: Communicating with Journalists. Scientists need to understand the role and purpose of journalism and its relationship to science. They also need to prep for media interviews in advance by determining the nature of the interviewer (staff reporter, freelancer, blogger or non-journalist) and the medium, checking on the credibility of the media outlet, and preparing to appear on camera.

Exercise 5. This exercise requires the participation of one or more working journalists. Invite workshop participants to the front of the room to interact with a reporter in different settings, including conventional interviews as well as informal settings like elevator encounters. Each scenario should last 1-10 minutes depending on the nature of the questioning. Other learners can then offer feedback.

Additional Resources

Books and Articles

1. Am I Making Myself Clear?: A Scientist's Guide to Talking to the Public, Cornelia Dean, 2012.
2. Championing Science: Communicating Your Ideas to Decision Makers, Roger and Amy Aines, 2019.
3. Escape From the Ivory Tower: A Guide to Making Your Science Matter, by Nancy Baron, 2010.
4. Explaining Research: How to Reach Key Audiences to Advance Your Work, by Dennis Meredith, 2021.
5. If I Understood You, Would I Have This Look on My Face?, by Alan Alda, 2018.
6. Strategic Science Communication: A Guide to Setting the Right Objectives for More Effective Public Engagement, by John Besley and Anthony Dudo, 2022.



Online Resources

7. Science communication programs from The Alan Alda Center for Communicating Science, as well as the center's blog, The Link
8. Trainings and programs from COMPASS Science Communication
9. The Story Collider podcast
10. Science Communication blogs from PLOS

Module Set D: Managing Research Data

Module Authors

12 Data Management

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13 Programming

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12 Data Management

Introduction

This module contains best practices and recommendations for managing data within privacy, intellectual property, and other constraints. Effective management of research data entails deploying methods and strategies for the collection, quality assurance, analysis, and sharing of data produced by both funded and unfunded research. Data management practices in research projects are often governed by funder and publisher requirements, as well as by federal, state, and organizational policies. While this module discusses compliance with those external factors, it also emphasizes the intrinsic value of good data management practices. Planning and application of strategies described in this module can provide myriad benefits, including improved efficiency, increased transparency and trust in results, and heightened personal and disciplinary impacts through data preservation and citation.

Learning Objectives

1. Recognize data management as a lifecycle process and a data management plan as a lifecycle document
2. Explain components of a data management plan and their relationship with the research lifecycle
3. Create, monitor and update a data management plan
4. Apply data sharing and preservation practices and principles

Themes and Exercises

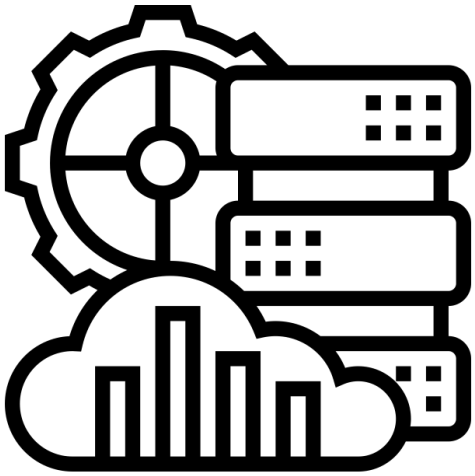
Theme 1: Research and Research Data Lifecycles. A comprehensive data management plan is a lifecycle document, in the sense that it spans the entirety of a research project, from planning to closeout. Each project incorporates two lifecycles: the research lifecycle, which encompasses acquiring and disseminating knowledge, and the research data lifecycle, which describes the processes by which project data is discovered, preserved and shared. Ten Simple Rules for Creating a Good Data Management Plan, by William Michener (2015), includes a general-purpose model describing the phases of each cycle. He defines the phases of the research lifecycle as: 1) formulate hypotheses and ideas, 2) acquire data, 3) analyze, visualize,

Research Lifecycle	Data Lifecycle: 1. Plan	2. Discover existing data	3. Collect and organize new data	4. Assure data quality	5. Describe the data	6. Use the data	7. Preserve the data	8. Share the data
1. Formulate ideas and hypotheses	★	★	★	★		★		
2. Acquire data		★	★					
3. Analyze, visualize and interpret data				★	★	★		
4. Publish and disseminate findings				★	★		★	★

Figure 12.1. The research and research data lifecycles.

and interpret, and 4) publish and disseminate findings. The research data lifecycle phases are 1) plan, 2) discover existing data, 3) collect and organize new data, 4) assure data quality, 5) describe the data, 6) use the data, 7) preserve the data, and 8) share the data.

These two lifecycles intersect at multiple points, as illustrated in Figure 12.1, above. Formulating ideas and hypotheses (research phase 1) can involve collection and preliminary analysis of subsets of relevant data, as well as budgeting and assigning roles and responsibilities for larger-scale data collection. Data acquisition (phase 2) requires planning, acquisition of existing data, creation of new data, and assuring the quality of acquired data. Analysis, visualization, and interpretation of research data (phase 3) requires the description of data in support of publication of analysis results and the use of data to answer research questions. Data-specific activities for publishing and disseminating findings (phase 4), include the identification of a suitable repository for sharing and archiving data, and transforming and describing data for publication.



by Eucalyp from the Noun Project

This research data lifecycle model is iterative, in that it may not progress through the phases in order but will often repeat phases as a project progresses. This has implications for data management planning – for example, rather than share and preserve data at the end of a project, researchers have to be prepared to share and archive relevant data upon publication of related findings, and to share documented data with collaborators throughout the research process. It is worth noting here that beginning in 2027, products of federally funded research, including both peer-reviewed articles and corresponding datasets, must be made publicly available immediately upon publication.

Exercise 1. Ask participants to list the standards, methods, and applications that they commonly use, or which are commonly used in their discipline, to accomplish the tasks in the different phases of the research data lifecycle. Encourage them to be as specific as possible about the types of metadata and other documentation they create or collect, and which, if any, metadata standards they use in doing so.

Theme 2: Data Management Plans (DMPs). Many funders require researchers to submit a brief (2-page) data management plan with their proposals. In general, plans are expected to describe 1) the types and amount of data to be collected or created, including data from existing sources or external third parties; 2) data and metadata formats; 3) policies for access and sharing; 4) policies for reuse and redistribution, and 5) plans for sharing, archiving and preservation, including specific repositories. Metadata refers to summary information about a data item, such as its author, date created, date modified, and file size, which makes it easier for a user to search for and locate the item.

Michener's DMP Recommendations

1. Determine the research sponsor requirements
2. İdentify the data to be collected
3. Define how the data will be organized
4. Explain how the data will be documented
5. Describe how data quality will be assured
6. Present a sound strategy for data storage, backup, and preservation
7. Define the project's data policies
8. Describe how data will be disseminated
9. Assign roles and responsibilities
10. Prepare a realistic budget

DMP requirements differ across funding organizations, and can also differ across directorates or divisions of a single funder. It is important for researchers to check the specific requirements of a funder and/or directorate, and also the level of specificity called for by a solicitation. For example, a solicitation may require data be preserved in a particular repository, in which case researchers will need to note this in their plan and address any formatting or metadata requirements imposed by the repository. The

DMPTool website includes documentation and templates addressing the DMP requirements of many funders, as well as sample DMPs.

An effective internal DMP should be more detailed and comprehensive than the succinct plan submitted to a funder. Michener emphasizes the value of a comprehensive DMP as fundamental to any research project, and includes a set of recommendations for drafting a successful plan (see box, previous page.) Figure 12.2 (below) identifies points of intersection between these recommendations and phases of the research data lifecycle.

Exercise 2. Have learners read and evaluate sample DMPs from DMPTool or the NIH. Have them identify within the sample plans specific, named standards (such as Dublin Core or Ecological Metadata Language) and resources such as specific file formats, licenses, and repositories referenced in the plans.

Instruct learners to use DMPTool to create a draft DMP using an available template for a funder or directorate in their discipline. Where appropriate, have learners incorporate and adapt sample language for different sections and components as provided by their institution. As part of this exercise, learners can identify resources for developing and ensuring execution of these components, including both local resources and those commonly used within their discipline or community.

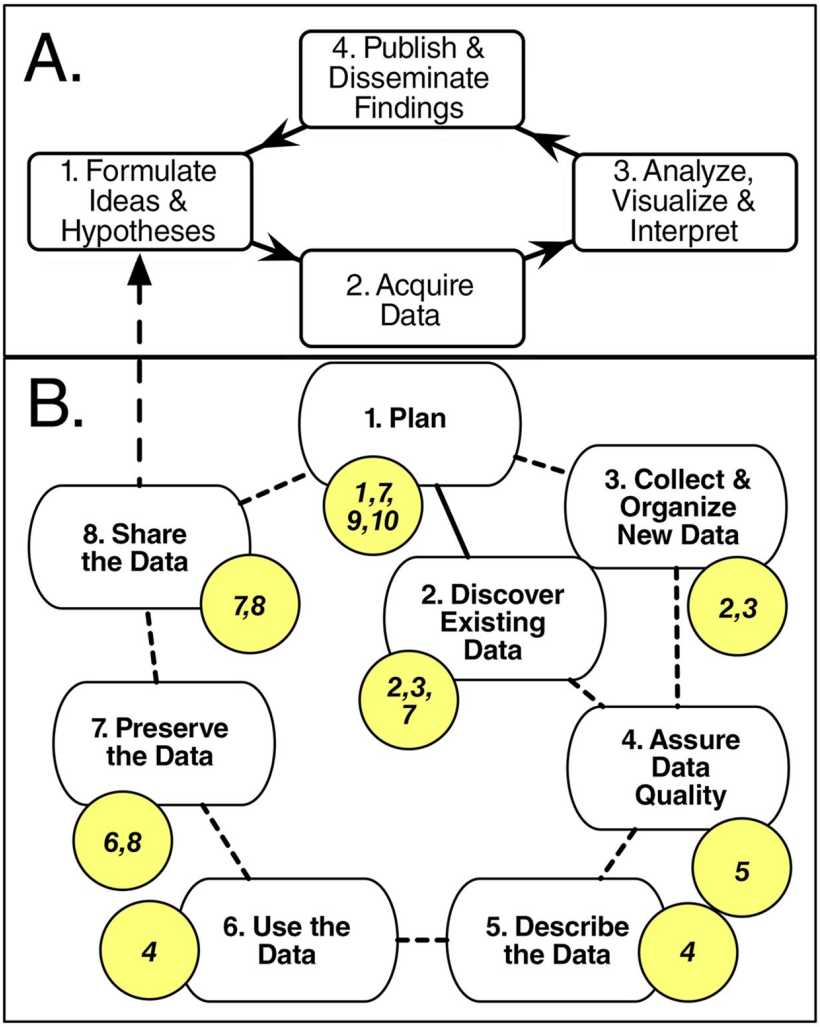


Figure from Michener (2015) under Creative Commons Attribution license

Figure 12.2. The research (A) and research data (B) lifecycles. The yellow circled numbers correspond with the recommendations from Michener (2015) outlined above.

Theme 3: Monitoring and Updating a Data Management Plan. Once developed, a DMP should be considered a living document subject to modification due to regulatory changes, evolving standards, etc. Keeping a plan in line with disciplinary best practices and compliance obligations requires monitoring the implementation of the plan as well as relevant external factors such as policy revisions and changes to third-party services. To this end, in addition to assigning specific roles and responsibilities for actions like data quality assurance, backup, and metadata processes, DMPs should also address: 1) Who will monitor implementation?; 2) Who is responsible for changing or updating a plan? and 3) What will be done in the event of a change in project personnel?

Many different factors require monitoring due to their potential impact on data management over the course of a project. These include:

- *Policy changes.* The number and scope of policies affecting research and data management can be complex, with multiple overlapping and sometimes contradictory requirements. Researchers should be aware of changes to federal, state, local, and institutional policies that impact data management and sharing, as well as publisher and repository policies.
- *Ethical considerations.* Current trends in ethical data management relate to respect for and meaningful collaboration with Indigenous peoples (see for example the CARE Principles for Indigenous Data

Governance, and to NIH Considerations for Informed Consent and Data Sharing). Funder expectations around data sharing include making data on human participants and other potentially sensitive data available and accessible to the extent possible with corresponding protections in place.

- *Other factors.* The DMP will include information about processes including metadata, quality assurance, backup and recovery, and timely data sharing. Successful implementation of these processes should be assessed through a periodic review and update of metadata, validation and restoration of data backups, and other strategies.

Exercise 3. Ask participants to identify individuals within their team or organization who will be responsible for implementing and assessing different components of the DMP, and specific strategies that will be used to monitor the plan. Roles and responsibilities should include personnel responsible for monitoring implementation, and for making required changes to the overall plan. Also instruct learners on local resources for staying abreast of policy changes, such as libraries and librarians, sponsored research support services and staff, and local compliance officers.

Figure 12.3. Factors to consider in crafting a Data Management Plan.

Theme 4: Data Sharing and Preservation. Data sharing and preservation are key components of data management policies and expectations. A successful data management plan must take into account a combination of sharing and preservation requirements, associated standards, and supporting principles (Figure 12.3). Three different sets of principles are often used to govern sharing and preservation efforts. The TRUST Principles define the general characteristics of trustworthy digital repositories. The FAIR Principles "put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals." And the CARE Principles for Indigenous Data Governance are "people and purpose-oriented, reflecting the crucial role of data in advancing Indigenous innovation and self-determination."

One common category of data sharing and preservation requirements relates to maintaining confidentiality and privacy of participants in human subjects and clinical research projects, consistent with regulatory (e.g. Health Insurance Portability and Accountability Act [HIPAA] and Family Educational Rights and Privacy Act [FERPA]) and participant consent requirements as stipulated by an institution's Internal Review Board. Also common are requirements for making data available for discovery, access, and reuse through repositories that support long-term preservation and access to shared data products; documentation of research data within the repository that enables its effective discovery, understanding, and use; data formats and policies that support long-term preservation and use; citation using persistent identifiers that remain stable through time; and clear license terms that define the rights and obligations of users of the data in a repository.

A common expectation across federal data sharing requirements is that data should be freely accessible to the largest possible group of users through minimal effort. Practices like sharing data by email request or via a project or departmental website do not sufficiently satisfy requirements for public access or data preservation. Instead, researchers must place their research data products into appropriate disciplinary

or general-purpose repositories that support sharing and preservation that is compliant with relevant requirements, standards, and principles.

Exercise 4. Have participants revisit the DMP created in Exercise 3 and assess its alignment with the requirements, standards, and principles for data sharing and preservation outlined in Theme 3, above. Make sure the DMP includes a documentation and metadata development strategy for execution throughout the project. Refer attendees to Cornell University's guide to "readme" style metadata to support consolidation of project documentation and metadata into a format useful for repository upload.

Exercise 5. Facilitate a group discussion about which overlapping requirements and guidance (such as CARE and FAIR; or CARE, FAIR, and human subjects participant confidentiality) should be implemented in different research data contexts.

Additional Resources

Books and Articles

1. Operationalizing the CARE and FAIR Principles for Indigenous Data Futures, by Stephanie R. Carroll et al., 2021.
2. A Competency Framework for Digital Curation and Data Science, by Sheila Corrall, 2013.
3. An Investigation on Core Competencies of Data Curator, by You-Kyoung Lee and Eunkyung Chung, 2015.

Online Resources

4. Data Science Competency Framework from Data to Decisions CRC
5. Desirable Characteristics of Data Repositories for Federally Funded Research from the Subcommittee on Open Science of the National Science and Technology Council
6. Disciplinary Metadata guidance from the Digital Curation Centre

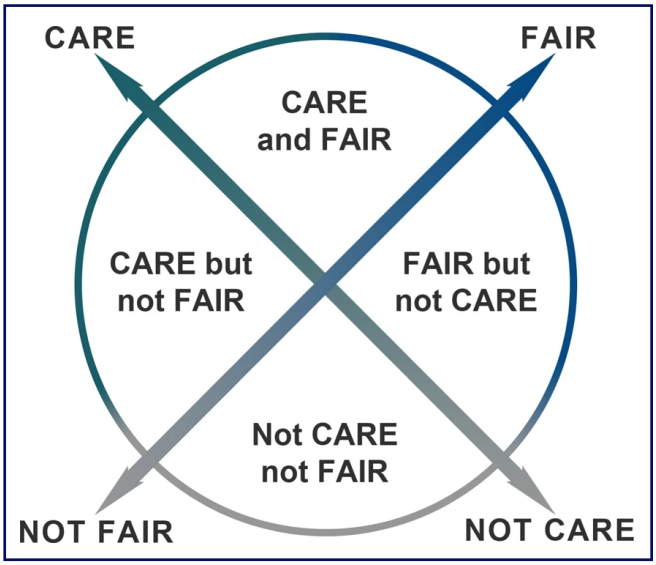


Image from "Operationalizing the CARE and FAIR Principles for Indigenous Data Futures" by Carroll et al. (2021).

13 Programming

Introduction

This module focuses on introducing fundamental concepts common to many programming languages. Hands-on components of the module demonstrating these fundamental concepts in R and Python may be adapted from existing, open-source materials, with reference to more advanced tutorials. The course can be supplemented by longer-format courses in more advanced topics, such as workshops by the Software Carpentry and Data Carpentry organizations. A second focus of the module is generally applicable strategies for developing reproducible research. As such, more advanced computer science topics and discipline-specific computational methodologies are out of scope. Finally, as use of non-open source applications and tools can incur costs that might inhibit participation, the module primarily refers to open-source languages and applications.

Learning Objectives

1. Identify common programming use cases (e.g., research, web development, dashboards, data science, machine learning, database development) and candidate languages and applications across disciplines
2. Describe strategies for developing reproducible research outcomes when programming or collaborating with teams on programming projects (or open research)
3. Demonstrate application of fundamental programming concepts that are common across language.
4. Identify goals for continued programming education and locate relevant resources

Themes

Theme 1: Common Use Cases for Programming.

Learners often have a specific need or programming use case in mind. While these are motivating because of their immediate relevance to real-world applications, they may require complex workflows or a deep skill set that learners don't yet possess. Approaches to identifying use cases for learning a new programming language include automating routine tasks, batch processing file or data management processes (renaming files, backing up data, etc.), and web scraping. Exercise 1 can be used at the outset of a workshop to provide an initial assessment of learners' motivations for programming and identify any previous programming experience.

It is useful to identify strengths of specific languages and applications that can be applied to common use cases. In particular, Python and the R statistical programming language are two open source applications/languages that are widely used in academia. Both languages are under active development, with large user bases, extensive documentation, and a large suite of open-source, community-developed libraries and packages that are optimized for a broad range of research workflows. Both languages are robust and mature. Although there is overlap in the capabilities of both languages, some differences are worth considering when deciding on a language to introduce to a specific group of learners:

- Python may be more familiar or have more direct research applicability for learners in computer science and engineering disciplines. It is a popular language for web development and for workflows that require interaction with third-party application programming interfaces (APIs), machine learning, data harmonization, and text mining.
- R has commonly been used by researchers in statistics-oriented disciplines, and currently supports research workflows across many other disciplines and methodologies. R is well known for its powerful

plotting capabilities, with many robust and freely available packages for creating publication quality figures and tables. Common applications of R include data harmonization, data cleaning, visualization, and statistical modeling.

Overlap between the two languages is again noted. For example, there are robust graphics and plotting libraries available for producing publication-quality figures in Python, while R also offers powerful functionality for interacting with APIs, machine learning, and text mining. Decisions about which language to teach will generally be guided more by common practice within specific disciplines and similarities to other applications used in the field. Learners looking for an open source alternative to MATLAB are more likely to be interested in Python, while those who are familiar with statistical and tabular data platforms including SPSS, STATA, and Excel may realize a more immediate benefit to learning R.

Both compiled languages and interpreted languages are relevant to the concept of integrated development environments (discussed below and demonstrated in Exercise 3), scripted workflows, and common use cases for different languages.

- Compiled languages include C, C++, and Java. Code written in these languages must be compiled into an executable file or application in order to run.
- Interpreted languages include Python, R, and JavaScript. Commands and code written in these languages do not need to be compiled. This can simplify development but requires users to install application environments that will interpret and execute code.

1. Ask participants, individually or in pairs, to identify their purpose(s) for programming, and to describe their experience with programming (or lack thereof). Ask them to identify which programming languages they would like to learn (in addition to the specific language being taught at the workshop) and which they may already be familiar with. Have learners define their concrete goals and outcomes for programming, and also help them to identify routine tasks that they can automate.

Theme 2: Programming and Reproducible Science. Reproducible science is a large topic and some aspects may be out of scope for a programming workshop. The Wilson et al. article Best Practices for Scientific Computing provides context for practices that support reproducible science. Reproducibility is a tenet of open science, and in order for findings and results to be reproducible researchers should document their data collection, quality assurance and control processes, data cleaning and aggregation, analysis, methods, etc.

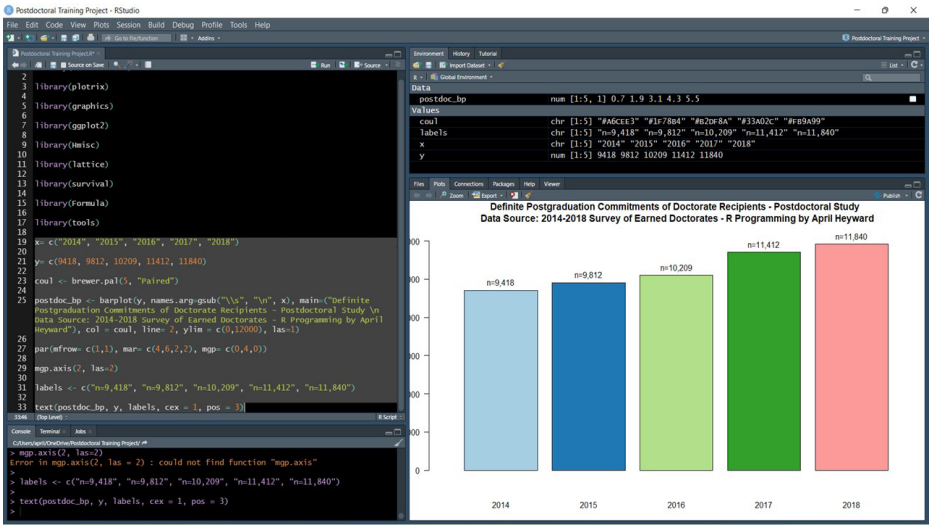


Figure 13.1. Programming in RStudio IDE by April Heyward.

"*Write programs for people, not computers*" and "*Document design and purpose, not mechanics*": A key concept common to these two recommendations is the differentiation between making code understandable to human readers (human readability), versus ensuring that code runs correctly and produces valid and reliable results (machine readability). Code that is not well documented may still run in six months or five years, but without sufficient documentation other researchers (including the developer's future self) may not be able to use it. In addition to documenting the inputs, outputs, and dependencies of a script, researchers should include human-readable descriptions of what a given piece of code does. Other strategies for developing

well-documented, human-readable code include using descriptive names and consistent formatting for variables and functions.

Don't repeat yourself: Common use cases for teaching and learning a new programming language include batch processing or automation of routine tasks. Automating scripted workflows eliminates errors that result when people do too many repetitive tasks. Computers do not become bored or distracted, and scripted workflows are less likely to result in typos, inconsistently named files, and accidental deletion or misplacement of raw data. Emphasize with learners that any tasks they find themselves doing repeatedly should be considered as programming use cases. This applies as well to commands and segments of code: Modularizing repeated lines of code into reusable functions makes code easier to read and debug.

Exercise 2. Have participants review the article Best Practices for Scientific Computing. Identify specific strategies for collaborating with teams on programming projects, and sharing citable software products for reuse.

Theme 3: Fundamental Programming Concepts. The number of concepts which can be demonstrated and practiced by learners will vary depending on the length of a workshop. A full workshop touching on all of the concepts below will take approximately four hours. For shorter workshops, concepts are listed below in priority order. For example, a two-hour workshop might cover development environments, variables and data types, and a single data structure such as lists (Python) or data frames (R). Additional concepts in a longer or "Part 2" workshop could introduce additional concepts in the order provided here. Hands-on examples and exercises should build upon a single example context and dataset to develop a sample analytic workflow.

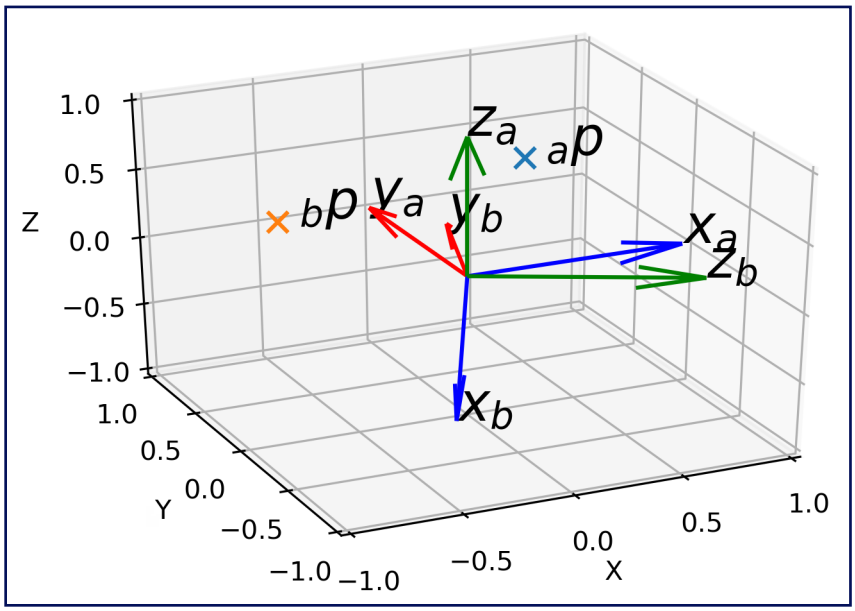


Figure 13.2. 3D graphic created in Python.

As described in Exercise 3, this theme can be broken down into multiple exercises to develop specific competencies in a particular language or application.

1. Development environments: Interpreted languages like R and Python require interpreters. Workflows and scripts are typically developed using an integrated development environment (IDE). An IDE is an application that bundles an interpreter together with a text editor for writing scripts, a file system navigation utility, and a 'variable explorer' that allows developers to monitor and debug script execution. Other common features include code completion, color coding, and version control. All of these features support code development and testing with improved efficiency compared to developing code using just a text editor or a command line console. Many IDE features will need to be described and demonstrated for novice learners as part of the hands-on practice.

The most commonly used IDE for R is RStudio. There are many commonly used Python IDEs. Robust, well-supported and freely available development environments for Python include Spyder and PyCharm. Jupyter Notebooks are also commonly used to teach Python, though Jupyter Notebooks do not have all of the IDE features described above. Spyder, PyCharm, and Jupyter Notebook environments are all included in the Anaconda Python distribution.

Learners should be encouraged to use any IDE that they may already be familiar with. Instructors should be prepared to recommend and demonstrate a specific IDE for other learners.

2. Variables and data type: The value of a variable can be assigned and modified as multiple points within the execution of a script. Different languages have different variable naming requirements. In the case of both R and Python, these include beginning a variable name with a letter and using only letters, numbers, and underscore characters in the rest of the name. Regarding reproducibility, it should be emphasized that descriptive variable names support development of human-readable, reusable code. That is, variable names like 'n' will be less informative in the long term than names like 'average_blood_pressure.'

Data type is a key attribute of a variable. Both Python and R include several data types, but the most important to define in an introductory workshop are numeric (integer and floating point), and non-numeric text ('string' in Python and 'char' in R). Depending on the content selected for the hands-on practice, other data types requiring definition may include logical ("True/False") and factors (in R a factor is a data type that refers to categorical variables).

3. Data structures: Data structures represent the logical arrangement or ordering of data held in the computer's memory during code execution. Both R and Python use similar data structures, but the terminology can vary. While it will not be possible to introduce every data structure in either R or Python, the most important for novice learners are:

a. Python:

i. Lists: If only one data structure is addressed in a Python workshop, it should be lists. A Python list is an ordered, mutable collection of objects. Lists maintain objects in the order in which they are added and individual objects can be changed or updated.

ii. Dictionaries: Python dictionaries are unordered, mutable collections of key:value pairs. Keys and values can be modified, but Python does not necessarily maintain these pairs in the order in which they are added. Instead, keys are indexed to allow for fast retrieval.

b. R:

i. Vectors: A vector is an array of values. By analogy with spreadsheets or other tabular data representations, a vector is similar to a column of values. All values within a vector possess the same data type.

ii. Data frames: By definition, an R data frame is a list of vectors. Using the same analogy as above, a data frame is comparable to a table in which columns represent variables and rows represent individual observations.

4. Flow of execution: Scripts are generally not linear in the sense that execution doesn't always begin at the first line and then proceed, line-by-line, to the end. Instead, it can be more efficient and result in cleaner, more human-readable code to repeat operations using a loop. Alternatively, different lines of code may be passed over or executed depending on specified conditions. Incorporating loops and conditional logic within code allows developers to write flexible, robust workflows that can be applied to multiple datasets or use cases.

a. Loops and iteration: Batch processing, automating routine tasks, and other workflow processes often require repeating a set of operations multiple times on a group of objects. Within a script, these iterative processes are accomplished using loops. There are two common types of loops in both Python and R:

i. 'For loops' execute a set of operations over every object in a collection.

ii. 'While loops' are similar, except that iteration ceases once a specific condition has been met.

b. Conditionals: The flow of code execution can also be controlled using conditional statements, which are logical expressions that are evaluated in the order they are given. If the first condition is met, the script executes a certain set of operations or lines of code. If the first condition is not met and there are additional conditions, each additional condition is evaluated in order. Once a condition is met and the corresponding operations are performed, the script bypasses any remaining conditions.

Discussion and demonstration of flow of execution provides another good intersection between programming and research reproducibility. Code should be sufficiently well-documented that users are able to trace the execution of a process from its beginning, through the definition of variables and their modification via loops, to different execution paths and outputs depending on logical conditions. Loop variables should follow the same naming conventions as other variables.

5. Data visualization and plotting: Developing a plot or visualization is an iterative process that benefits from a scripted approach in which researchers can experiment with different arguments and styles to develop plots that communicate results clearly. R and Python both feature packages and libraries that can be used to create publication-quality figures and tables (ggplot2 in R and matplotlib in Python).

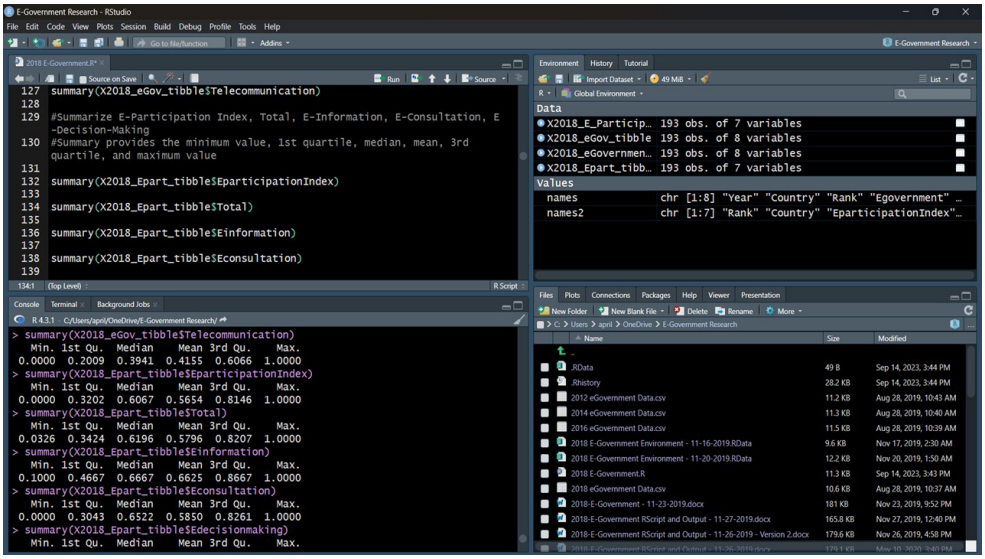


Figure 13.3. Programming in RStudio IDE by April Heyward.

Three common use cases include visualizing trends, comparisons, and plotting relationships. In each case, key points to address with learners include the selection or aggregation of variables corresponding to the X and Y axes of a plot, effective use of color and shape to highlight useful or important aspects of the data, and methods for labeling plots, axes, and legends.

6. Functions: Functions are reusable bits of code. Certain steps may be repeated multiple times within a computational workflow. Examples include opening files, generating output files or plots, standardizing dates, or calculating statistics using updated data values. When processes are repeated over and over, copying and pasting relevant lines of code can result in long scripts that are difficult to read and troubleshoot. Alternatively, the code or operations that are being repeated can be used to define a function. Code within a function is written one time, and when needed at different points within a script, can be executed by calling the function.

In terms of research reproducibility, functions allow developers to encapsulate routine or repeated workflow processes in a reusable way. This simplifies documentation, and the ability to define and pass different arguments to functions enables a single function to be used for multiple different purposes while keeping scripts short and facilitating human-readability.

Exercise 3. This hands-on practice session will provide learners with a chance to apply basic skills in programming that includes concepts common across programming languages: variables, data types, data structures, loops, conditions, visualization, and functions. Note that although listed as a single exercise here, the majority of a workshop will consist of an iterative cycle of 1) defining a programming concept and providing a demonstration, 2) providing learners an opportunity to apply the concept through a worked example, and 3) checking for understanding with exercises and collective troubleshooting.

New tutorials developed for the hands-on practice will be most effective if developers use a single, open dataset and scaffold a series of worked examples that learners can refer to. The dataset should be assessed for relevance to the learner group. Small, well-documented tabular datasets with readily understood variables are recommended. A good example is the Portal Project Teaching Database which is used in several Software and Data Carpentry lessons.

Note that many open-source and openly licensed tutorials exist. The example tutorials referenced here include open datasets, worked examples and exercises, and generally follow the order of concepts recommended above. Use or adaptation of these or similar, pre-existing hands-on materials is encouraged as an alternative to developing new tutorials. The Software and Data Carpentry lessons in particular have been through extensive vetting and peer review and are continually updated by teams of maintainers. Freely available and openly licensed tutorials include:

Software Carpentry:

- Programming with Python
- Plotting and Programming in Python
- Programming with R
- R for Reproducible Scientific Analysis

Data Carpentry:

- Data Analysis and Visualization in R for Ecologists
- Data Analysis and Visualization in Python for Ecologists

Theme 4: Methods and Resources for Debugging Code. This modele includes a bibliography of references and resources, including tutorials, official documentation and developer guides. While there are an abundance of resources and communities that learners can turn to for assistance troubleshooting, there are conventions for framing questions in ways that facilitate getting useful answers from communities like Stack Overflow, Slack, and others. Common strategies include doing a web search using an error message, exporting a 'stack trace' (see below) and including it together with relevant code in a post on Stack Overflow, and using help functions and documentation within the IDE.

It is useful to note that the execution of a single line of code may involve calls to other functions, methods, and libraries or packages. The execution of that line of code can result in the further execution of potentially many other lines of code that are external to the script itself. A full error stack trace provides the line within a script that produced the error, but also includes relevant sections of code from those other functions. Both Python and R have special functions for exporting an error's stack trace.

Exercise 4 can be used at the close of a workshop to help learners specify concrete programming goals and identify helpful resources for accomplishing those goals.

Exercise 4. Have participants Identify an independent learning path for continued programming education. Participants identify resources from the bibliography provided below that they will use for continued learning. Learners may also identify a helpful resource they've used or heard of which is not on the list and add it to a shared bibliography.

Additional Resources

Resources for Programming Module Developers

1. The Carpentries Curriculum Development Handbook, by Erin Becker and François Michonneau, 2022.
2. Software Carpentry: Programming with R, by John Blischak, Daniel Chen, Harriet Dashnow, and Denis Haine (eds), 2016.
3. Software Carpentry: Programming with Python, by Azalee Bostroem, Trevor Bekolay, and Valentina Staneva (eds), 2016.

4. Data Carpentry: Data Analysis and Visualization in Python for Ecologists, by John Gosset and April Wright (eds), 2017.
5. Software Carpentry: Plotting and programming in Python, by Allen Lee, Nathan Moore, Sourav Singh, and Olav Vahtras (eds), 2018.
6. Data Carpentry: Data Analysis and Visualization in R for Ecologists, by F. Michonneau et al., 2023.
7. Teaching Tech Together, by Greg Wilson, 2019.
8. Best Practices for Scientific Computing, by Greg Wilson et al., 2014
9. Software Carpentry: R for Reproducible Scientific Analysis, by Naupaka Zimmerman, Greg Wilson, Raniere Silva, Scott Ritchie, François Michonneau, Jeffrey Oliver, and Yuka Takemon, 2019.

Book Resources

1. Neural Networks with R, by Giuseppe Ciaburro and Balaji Venkateswaran, 2017.
2. Regression Analysis with R, by Giuseppe Ciaburro, 2018.
3. Hands-On Exploratory Data Analysis with R, by Radhika Datar and Harish Garg, 2019.
4. Database Design for Mere Mortals: 25th Anniversary Edition, by Michael J. Hernandez, 2020.
5. Hands-On Time Series Analysis with R, by Rami Krispin, 2019.
6. Machine Learning with R, by B. Lantz, 2019.
7. Text Mining with R, by Julia Silge and David Robinson, 2017.
8. Bayes' Rule with R: A Tutorial Introduction to Bayesian Analysis, by James V. Stone, 2016.
9. R for Data Science, by Hadley Wickham and Garrett Grolemund, 2017.

Programming Languages/Software Resources

1. Bioconductor R Programming
2. C ++ Programming
3. Java Programming
4. MATLAB
5. Microsoft SQL Server
6. MySQL
7. PostgreSQL
8. Python Programming
9. Jupyter Notebook
10. RStudio IDE
11. R Markdown
12. The R Project for Statistical Computing (Base R)

Programming Independent Learning Resources

(Note that some online courses and materials may have associated costs)

1. edX (Search "Programming")
2. LinkedIn Learning (Search "Programming")
3. Udemy (Search "Programming")

Other Programming Resources

1. GitHub
2. RDocumentation
3. Stack Overflow
4. The Comprehensive R Archive Network (CRAN)