Improving Undergraduate Research Experiences:
The Merits of Training Mentors

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Abstract

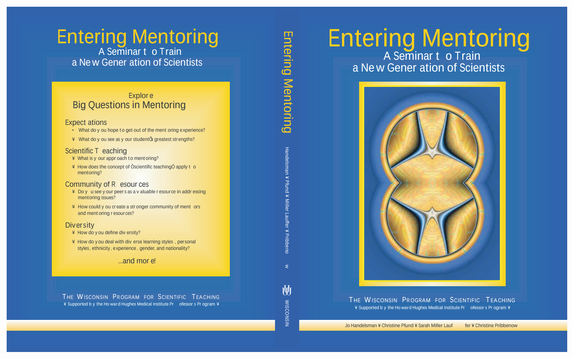
Substantial resources are dedicated to providing undergraduates with mentored research experiences to increase interest and broaden participation in the sciences. The quality of these research experiences depends on effective mentoring, yet most mentors are not provided training. To fill this gap, we developed and evaluated a seminar to help mentors become more effective. Data collected from pre-faculty mentors and their undergraduate researchers show that the seminar enhances mentors' relationships with both their undergraduate researchers and, unexpectedly, their faculty advisors. These results have implications for the design of undergraduate research experiences and training of current and future faculty

Example Mentor Training Seminar Syllabus

Dates	Topics	Assignments Due	Readings
Week 1	**Getting Started** • Introductions • The elements of a good research project • Establishing a good relationship with your mentee		"Teaching Scientists to Teach" J. Handelsman "Scientific Teaching". J. Handelsman *et al*.
Week 2	**Learning to Communicate and Establishing Expectations** • Case study: projects • Mentees and their projects • Establishing expectations – the mentor's and the mentee's	1. A paragraph describing your mentee's project 2. A written mentoring philosophy	
Week 3	**Understanding** • Discuss mentoring philosophies • Case Study: Understanding • How do you know that they understand what you are saying?	1. A short biography of your mentee with information you gather from interviewing them. 2. Summary of the discussion you and your mentee had about expectations.	"What is a mentor?" in *Advisor, Teacher, Role Model , Friend* by NAS
Week 4	**Mentoring Challenges** • Case studies from your first few weeks – challenges and suggestions • How do you know if there are problems?		"Mentoring Learned, Not Taught"; J. Handelsman
Week 5	**Addressing Diversity** • Proposed solutions to the case studies • Case Studies: diversity • Mid-course process check	A written proposal of a possible solution to one of the challenges described during a previous mentoring discussion.	"Benefits and Challenges of Diversity"; WISELI
Week 6	**Ethics** • Ethics Case Study • Mid-course process check	Thoughts about how you and your mentee differ. How do these differences affect the summer experience for both of you?	
Week 7	**The Elements of Good Mentoring** • What can we learn from other mentors? • What has proven effective in your mentoring? • Presentations	Present one of your mentoring challenges to your PI (or another you respect as a mentor) and ask how they would handle the situation. Submit a summary of their response and what you thought about it.	"Righting Writing"; J. Handelsman
Week 8	**Developing a Mentoring Philosophy** • Mentoring philosophies after the mentoring experience	Rewritten mentoring philosophy	

Example Biology Case Study: Trust

A graduate student mentor was frustrated because her student was not running successful experiments. While the undergraduate had great enthusiasm for the project, each experiment failed because of some sloppy error—forgetting to pH the gel buffer, forgetting to add a reagent to a reaction, or forgetting to turn down the voltage on a gel box. After a month of discussions and careful attempts to teach the student habits that would compensate for his forgetfulness, the graduate student was ready to give up. She spoke with her adviser and asked for advice, hoping that she could fix the problem and start getting useful data from her undergraduate. The adviser offered to work with the undergraduate mentee. When the undergraduate walked into his office, the faculty member said, "I hear you're a slob in the lab. You gotta clean up your act if we're going to get any data out of you." Seeing the crushed and humiliated look on the undergraduate's face, he quickly added, "I'm a slob too—that's why I'm in here pushing papers around and not in the lab doing the hard stuff like you guys!"



Book is available at http://scientificteaching.wisc.edu/

Table 2 : Mentor satisfaction with discussion topics in the Mentoring Seminar

Discussion Topic in Mentoring Seminar	Respondents who found the topic useful and interesting (%)
Identifying the elements of a good research project	77%
Establishing a good relationship with mentee	91%
Designing research projects	64%
Setting goals and establishing expectations	79%
Sharing mentoring challenges with each other	83%
Designing approaches to address mentoring challenges	79%
Addressing issues of diversity	66%
Evaluating your own progress as a mentor	81%
Articulating a mentoring philosophy	74%

Values represent the percentage of 47 respondents from eight institutions, including the University of Wisconsin-Madison.

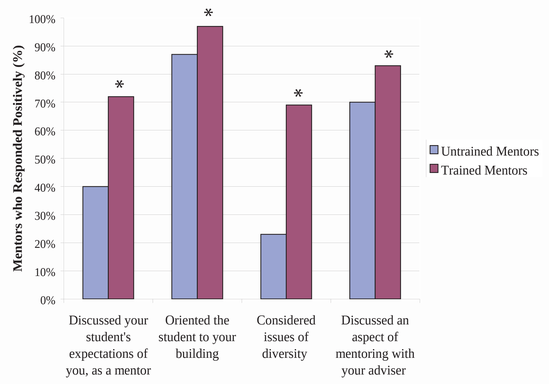


Figure 1: Percentage of mentors who indicated that they engaged in the noted activity while mentoring an undergraduate researcher. Stars indicate the that the difference between the trained and untrained mentors was significant (P < 0.05).

Table 3a-c: Self-report gains of mentees as reported by the mentees themselves and their mentors and the alignment of those ratings(Pfund, et al. Science, 2006)

Table 3a: Self-reported skill gains by undergraduate researchers at the University of Wisconsin-Madison.

Self-Reported Skill of Undergraduates	Skill Rating (mean) (1) no skill; (2) very low skill; (3) low skill; (4) moderate skill; (5) high skill; (6) very high skill			
	Undergraduates working with trained mentors (n=25)		Undergraduates working with untrained mentors (n=59)	
	BEFORE	AFTER	BEFORE	AFTER
Your research skills, in general	**3.25**	**4.88**	**3.42**	**4.91**
Developing a research project	**2.67**	**4.38**	**3.02**	**4.58**
Working independently on research	**2.71**	**4.71**	**3.35**	**4.84**
Conducting a research project	**2.96**	**4.71**	**3.12**	**4.79**
Articulating questions	**3.71**	**4.58**	**3.86**	**4.63**
Receiving feedback	**4.17**	**4.83**	**4.16**	**4.88**

All gains were significant ($p<0.05$). No significant differences were detected between undergraduate researchers working with trained and untrained mentors. The six categories in bold were used for the alignment analysis shown in Table S7c.

Table 3b: Skill gains in undergraduate researchers as reported *by mentors* in six categories at the University of Wisconsin-Madison.

Mentor-Reported Skill of Undergraduates	Skill Rating (mean) (1) no skill; (2) very low skill; (3) low skill; (4) moderate skill; (5) high skill; (6) very high skill			
	Undergraduates working with trained mentors (n=28)		Undergraduates working with untrained mentors (n=59)	
	BEFORE	AFTER	BEFORE	AFTER
Your research skills, in general	3.00	4.43	2.83	4.57
Developing a research project	2.50	3.82	2.61	4.13
Working independently on research	3.46	4.39	3.48	4.65
Conducting a research project	2.89	4.32	2.65	4.30
Articulating questions	3.82	4.61	3.43	4.35
Receiving feedback	3.79	4.46	3.78	4.52

All gains were significant ($p<0.05$). No significant differences were detected between undergraduate researchers working with trained and untrained mentors as rated by their mentors. These six categories were used for the alignment analysis shown in Table S7c.

Table 3c: Alignment of ratings of undergraduate skills by undergraduates and their corresponding mentors.

Skills of undergraduates	Significance of difference between mentors' and undergraduates' ratings of undergraduate skills	
	Untrained n=28	Trained n=57
	p-value	p-value
Your research skills, in general	0.004*	0.118
Developing a research project	0.01*	0.273
Working independently on research	0.25	0.230
Conducting a research project	0.01*	0.422
Articulating questions	0.08	0.564
Receiving feedback	0.05*	0.142

Skill ratings from the top six categories in Tables S7a and S7b were used for this analysis. *indicates a significant difference between ratings given by undergraduates and ratings given by corresponding mentors using general linear, repeated measures tests.

Adaptations to Other Disciplines

Example Questions to Address in the Adaptation of Mentor Training for Use Across Stem

Core Topics	Sample Questions
Designing a research project	• How can mentors design projects to best meet the needs, backgrounds, and abilities of their mentees? • How does project design influence a mentee's image of STEM disciplines? • What can realistically be accomplished in a specific field in a given time frame?
Establishing a relationship	• What do mentors need to know about their mentees before they start working together? • What background information in each discipline does a mentee need to know before starting research? How can a mentor assess a mentee's mastery of this content?
Setting expectations	• What can mentors expect from their mentees? What can mentees expect from their mentors? Are these expectations realistic? • Do expectations vary among disciplines? Do expectations vary among individual students? Should they?
Fostering independence	• In each discipline, what constitutes an independent researcher? • Do different students require differing levels of independence? Do different types of research require differing levels of independence? • What are the risks and benefits of independence? How do these differ among disciplines?
Establishing trust	• How can mentors function both as advisors and evaluators? • Is it the obligation of a mentor to assess a mentee's potential in STEM? • How do students from different backgrounds view power dynamics and issues of trust? How might that impact the mentor/mentee relationship?
Addressing and maximizing diversity	• Who belongs in science? Who doesn't? • What role do mentors play in making science accessible? • Should every student have the opportunity to do research? • Does every student have the potential to be a researcher?
Communicating effectively	• How can mentors determine if their mentees understand? • What constitutes understanding in a specific field of study? • How important is it for mentees to learn to communicate their research effectively? To whom?
Developing a mentoring philosophy	• Do philosophies of mentoring differ among disciplines or groups of students? • Can a mentor have a core mentoring philosophy or does the philosophy change with each mentee? • Do mentors have an obligation to increase the representation of underrepresented groups in science? Should this be part of their philosophy?

Adaptations Across STEM

Adaptations Team

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