Spring 2020
Volume 11, Issue 1

Introduction to Research: A Scalable, Online Badge Implemented in Conjunction with a Classroom-Based Undergraduate Research Experience (CURE) that Promotes Students Matriculation into Mentored Undergraduate Research

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Appendices

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APPENDIX I: Introduction to Research Badge, Unit 1 Reflective Writing Prompts

Students should read the following articles before addressing the following reflective prompts:

- Slaughter, G. R. (2006b). Research and Work Experiences. In *Beyond the Beakers: SMART Advice for Entering Graduate Programs in the Sciences and Engineering*. Baylor College of Medicine.
- Lizarraga, D. (2011). *The Benefits of an Undergraduate Research Experience*. Retrieved from https://pathwaystoscience.org/pdf/SummerResearch_BenefitsOf.pdf
- Institute for Broadening Participation. (n.d.). *Summer Research Experiences for Undergraduates: What are they good for? How does it all work? Finding and Applying to Programs.* Retrieved from https://pathwaystoscience.org/pdf/SummerResearch_WhatWhyApplicationTimeline.pdf

Reflective prompts based on assigned reading (5 points each). Questions marked with an * are adapted from Branchaw, Pfund, and Rediske[1].

1. What are your career goals and research interests?*
2. Why do you want to do research? How will it help you reach your goals?*
3. What skills do you wish to develop by participating in undergraduate research?
4. What are you most excited about in regards to undergraduate research?*
5. What is your biggest concern regarding undergraduate research?*
6. When should you start looking for research opportunities?
7. Why do you think you are ready for undergraduate research? Reflect on your academic coursework and performance, laboratory experiences, and skills.
8. What do you think you should do between now and starting an undergraduate research experience to help you be successful?
9. What contributions can undergraduates make to a research team?
10. What contributions can you specifically make to a research team? Reflect on your strengths, prior coursework, skills, or training thus far.

Student Evaluation:

Each question was worth 5 points and students were awarded the points if they made an honest effort to address the question. When appropriate, formative feedback was provided based on the students' responses.

[1] Janet Branchaw, Christine Pfund, and Raelyn Rediske (2010). *Entering Research: A Facilitator's Manual. Workshops for Students Beginning Research in Science*. New York, NY: W.H. Freeman and Company (p. 31).

APPENDIX II: Introduction to Research, Unit 2 Undergraduate Research Experience Comparison Worksheet

Research the following undergraduate research opportunities – NSF REU, UMBC URA, MARC U*STAR, and NIH Internship – and fill out the worksheet below comparing the opportunities. You may use another sheet of paper to complete this assignment, if needed.

Research Opportunity	NSF REU	MARC U*STAR	UMBC URA	NIH Internship
Purpose of the research opportunity?				
Eligibility (GPA, academic standing, courses, specific skills needed, etc.)				
Program requirements (specific application materials needed) and due dates				
Commitment (timing, location, housing, etc.)				
Compensation				
When should you start looking for this opportunity and where can you find information?				

Student Evaluation:

Students received full credit (120 points) if they made an honest effort to complete the table.

APPENDIX III: Introduction to Research, Unit 2 NSF REU Opportunity Review

Part 1: Review four NSF REU Programs and prepare an outline of why they are interested (note, REU Programs should be updated based on whether they are active).

Research the below REU programs, determine the program that best fits your interests, and prepare a 1-page, bulleted outline of why you are interested in that program. This outline should include: 1) why you are interested in the program (i.e., how will it help you achieve your academic and/or professional goals), 2) specific skill sets that you will develop through participation in this program and 3) a description of at least one research mentor and/or project that you are interested in working on and why. The four REU programs students should review are:

- NC State University BioTechnology-Based Sequencing-based Undergraduate Research Experience (BIT SURE) - http://biotech.ncsu.edu/pages/nsf-reu
- OSU Robots in the Real World - http://robotics.oregonstate.edu/reu
- CSU REU in Molecular Biosciences
  - http://www.bmb.colostate.edu/undergraduates/reu/program-description/
- MSU Cross-Disciplinary Training in Sustainable Chemistry and Chemical Processes
  - https://www2.chemistry.msu.edu/web/reu/

A complete list of NSF REU sites that students can search to look for opportunities can be found at: https://www.nsf.gov/crssprgm/reu/reu_search.jsp.

Student Evaluation:

Students were provided formative feedback on their outlines, often encouraging them to provide more detail when addressing the prompts. This was a required assignment.

APPENDIX IV: Introduction to Research, Unit 2 Personal Statement Assignment and Rubric

Through completion of this personal statement, students will be able to:

1. Analyze past and current learning and research experiences and tie them to a future career in the STEM field.
2. Evaluate how the research opportunity will contribute to their future career a future scientist.
3. Critique a response to a challenge they have experienced.
4. Write a clear and effective personal statement that demonstrates clear and disciplinary appropriate language by writing multiple drafts

Crafting an effective personal statement is a crucial skill when applying for research positions, internships, graduate, or professional schools. Some employers even require personal statements in application packets! Therefore, students will draft a personal statement that is geared towards an undergraduate research program.

Personal statements describe your educational and career goals and provide reasons and motivation for pursuing these goals. Your personal statement should also address the following prompts:

- Why do you believe that a career in STEM is right for you?
- How will an undergraduate research program assist in your development as a future scientist?
- Describe a challenge you have faced (personal, group, academic, or other) and how you approached it.

Personal statements should be 1 page (single spaced, size 12 Times New Roman font, 1-inch margins).

Assessment: Students' personal statements were assessed via the rubric provided below. The rubric is guided after the AAC&U's Value Rubric[2] and aligns to the learning outcomes (LO) of the activity and UMBC's functional competencies (FC)[3].

[2] AAC&U's Value Rubrics can be found at: https://www.aacu.org/value-rubrics (last accessed June 13, 2019)
[3] UMBC's Functional Competencies can be found at: https://provost.umbc.edu/files/2016/04/UMBC-General-Education-Functional-Competencies-2005.pdf (last accessed June 13, 2019)

Criteria	Excellent (A)	Good (B)	Satisfactory (C)	Developing (D)
Prompt 1: STEM Career Fit (SLO 1, FC 3)	Draws on previous experience(s) and describes how they relate to a career in the STEM field. Provides explicit examples that clearly connect prior learning to future goals. Skillfully highlights educational and career goals and motivation(s) for pursing these goals.	Draws on previous experience(s) and describes how they relate to a career in the STEM field. Provides examples that connect prior learning to future goals. Highlights educational and career goals and motivation(s) for pursing these goals.	Draws on previous experience(s) and describes how they relate to a career in the STEM field. Examples are adequate but not strongly connected to future goals. Addresses educational and career goals and motivation(s) for pursing these goals.	Draws on previou experience(s) and how they relate t the STEM field. F minimal example or may not conne goals. Implies ed and career goals motivation(s) for these goals.
Prompt 2: Benefits of Undergraduate Research Program (SLO 2, FC 3)	Clearly and thoroughly analyzes what they will learn from undergraduate research and how they will apply it to their future careers. Provides distinct, concrete examples of how an undergraduate research program program will prepare them for this future.	Clearly analyzes what they will learn from undergraduate research and how they will apply it to their future careers. Provides concrete examples of how an undergraduate research program will prepare them for this future.	Analyzes what they will learn from undergraduate research and how they will apply it to their future careers. Provides examples of how an undergraduate research program will prepare them for this future.	Analyzes aspects they will learn fro undergraduate res provides glimpse they will apply it t future careers. Sh knowledge of hov undergraduate re program will prep for this future.
Prompt 3: Challenges (SLO 3, FC 3)	Skillfully critiques and interprets an approach to challenge. Offers thoughtful insights on how challenge may impact their future careers.	Critiques and interprets an approach to challenge. Offers insights on how challenge may impact their future careers.	Critiques an approach to challenge with some connection to future career goals.	Describes an app challenge with so connection to futu goals.
Style (use of language) (SLO 4, FC 1)	Uses language that skillfully communicates meaning to readers with clarity and fluency, and is virtually error-free.	Uses language that skillfully communicates meaning to readers with clarity and fluency, and has 2-3 errors that do not confuse readers.	Uses language that communicates meaning to readers with clarity and fluency, but has 2-3 errors that confuse readers.	Uses language th communicates so meaning to reader 4-5 errors that co readers.
Organization (coherence, connectivity) (SLO 4, FC 1)	Superb coherence and unity: strong lead in, excellent thesis that connects the prompts, logical progression of support paragraphs (with topic sentences), effective transitions, emphatic conclusion with transference.	Solid coherence and unity: nice lead in, good thesis, logical progression of support paragraphs, clear transitions, high quality conclusion with some transference.	Proficient coherence and unity: fair lead in, adequate thesis, mostly logical progression of support paragraphs, passable transitions, simple conclusion.	Developing coher unity: a lead in, m thesis, some logi progression of su paragraphs, pass transitions, simpl conclusion. Point shifts.

Comments on the strengths of the personal statement:

Comments on areas where the personal statement could

Personal Statement ID:

APPENDIX V: Introduction to Research, Unit 3 Sample Email Critique Assignment

Students were directed to the information posted below that is adapted from Branchaw, et al.[4] *Students were also directed to watch a short video from Elon University's Center for Engaged Learning*[5]*.*

Tips for Identifying Potential Research Mentors

1. Determine what interests you. In other words, define a research area (e.g., molecular biology, biology, materials science, nanotechnology, analytical chemistry, etc.). Remember, however, that doing research and the skills that undergraduate research provides (i.e., critical thinking, quantitative and scientific reasoning, technical skills) is more important than the topic of the actual research you conduct at this stage of your career.
2. Do a search of campus websites to identify faculty working in your area of interest. Search through department websites, student job sites (i.e. UMBCworks), and undergraduate research databases (i.e., UMBC URA). Talk to peers who are already doing research and faculty/staff about potential mentors. If you're not sure what research area interests you, then start by doing a general review of faculty research in the academic department in which you are majoring by reviewing departmental websites or attending departmental seminars. Remember that there may be faculty outside of your departmental major doing research in a field that you're interested in.
3. Read the faculty research descriptions on departmental websites and generate a ranked list of potential mentors and consider reading one or two of the mentors most recent publications. Identify at least one thing about each person's research that is interesting to you and that you would like to know more about.

Email is a great way to make initial contact with potential mentors. By sending an email you give the mentor a chance to review your materials before responding. It is like the first step in an interview, so be sure it reflects your best effort (no spelling or grammatical errors!). If you are comfortable, it is also OK to phone or stop by a potential mentor's office to ask about a research experience.

Some things to consider when composing an email to a potential research mentor:

- Research mentors are very busy people, so keep it short and to the point (approximately 1 paragraph). Also, do not expect an immediate response - you may not hear back very quickly and might need to send a follow up email.
- Address the email using the mentor's official title (e.g., Professor, Dr.).
- Specifically refer to the mentor's research and what you find interesting about it. Be sure to use your own words and not copy text from the research description on his or her website.

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[4] Content for this module is adpated from: Janet Branchaw, Christine Pfund, and Raelyn Rediske (2010). *Entering Research: A Facilitator's Manual. Workshops for Students Beginning Research in Science*. New York, NY: W.H. Freeman and Company (pps. 14-15).

[5] Center for Engaged Learning. (2014, November 13). Identifying an undergraduate research mentor. Retrieved from: https://www.youtube.com/watch?v=1mfC-UNTHPg

- Be clear about what you are looking for (i.e., a research experience vs. a dishwashing job) and what your main goal(s) will be (e.g., shadowing someone in the lab to get exposed to research vs. doing an honors thesis research project).
- Provide an estimate as to the number of hours per week that you are able to work - keep in mind that most mentors would like for students to work a minimum of 8-10 hours per week, with 2-3 hour blocks at a time.
- Realize that many mentors are not able to pay students, so be careful to not inquire about compensation. Instead show interest in the experience that you will gain and describe how you will benefit.
- Give a brief overview of your academic success (GPA, relevant courses completed) and consider attaching your unofficial UMBC transcript.
- Highlight what you have to offer and what distinguishes you from other students (e.g., hard worker, experience, eager to learn, willing to stay more than one semester, persistent, specific courses you've completed that are relevant to the research).
- Show professional enthusiasm for learning how to do research!
- Request that if the mentor is not able to take an undergraduate researcher, that they recommend a colleague who might be able to.
- Mention that you have completed the Introduction to Research (Discovery) online training!
- Make sure to send your email from your umbc.edu email address and proofread before you send! Your email should also include your complete contact information - full name, email, and phone number.

Student Assignment:

Critique two emails (below) that a student wrote to a potential mentor about conducting undergraduate research in their lab. Refer to content on previous page for details on crafting an effective email.

Email 1:

To: Dr. Steve Smith (ssmith@umbc.edu)

From: ilovecats42@yahoo.com
Subject: research

Hi Steve,

I'm looking to do research in a lab on campus. Do you have any opportunities?

Sally

Email 2:

To: Dr. Steve Smith (ssmith@umbc.edu)

From Sally Turner (sturner@umbc.edu)
Subject: undergraduate research opportunities

Dear Dr. Smith,

I am a sophomore at UMBC majoring in biology and interested in pursuing undergraduate research over the summer, as my career goals are to obtain a Ph.D. in molecular biology. I recently saw that your research interests involve understanding mechanisms of inflammation and was particularly interested in your work investigating the role of MARCKS in cell migration. I wanted to reach out to you to learn more about your research and discuss opportunities that you may have in your lab to conduct undergraduate research. I am a hard working and very motivated student who is eager to learn and I have a cumulative GPA of 3.87. Over the summer, I have approximately 20 hours per week to devote to research, as I will also be taking physics (PHYS 122). I have completed BIOL 141 and 142 (achieved an A in both) and am currently enrolled in BIOL 302 this semester. I also recently completed the Introduction to Research online training and am very excited to get started in research.

I look forward to meeting with you at your earliest convenience. I am available to meet before 10 am on Monday and Wednesdays, after 1pm on Thursdays, or anytime during free hour.

Many thanks in advance!

Best wishes,
Sally Turner

Student Evaluation

Students were given full credit (100 points) if they made an honest effort to critique the emails.

APPENDIX VI: Introduction to Research, Unit 3 Research Mentor Email Assignment and Rubric

Students have to find a researcher on campus that they are interested in working with and draft an initial email to the mentor inquiring about research opportunities in their lab. Students are encouraged to find research mentors by reviewing Departmental websites (see below).

UMBC Department of Biological Sciences: https://biology.umbc.edu
UMBC Department of Chemistry & Biochemistry: https://chemistry.umbc.edu
UMBC Department of Chemical, Biochemical, and Environmental Engineering: https://cbee.umbc.edu
UMBC Department of Mathematics & Statistics: https://mathstat.umbc.edu
UMBC Department of Mechanical Engineering: https://me.umbc.edu
UMBC Department of Psychology: https://psychology.umbc.edu

**NOTE, students do not have to actually send this email, unless they want to.

Student Evaluation

This assignment was worth 100 points and the following rubric was used.

Criterion	Outstanding	Satisfactory	Needs improvement	Comments
Professionalism Email is professional by using the mentor's formal title, professional language, and a formal salutation with the student's contact information.	*40 points*	*20 points*	*5 points*	
Content Student clearly and succinctly addresses their reasons for pursuing undergraduate research and what led them to contact the mentor (i.e., highlighting mentor's research interests). The student also conveyed their availability, GPA and/or courses taken, or what skills/characteristics make them ready for undergraduate research.	*30 points*	*15 points*	*5 points*	
Grammar and Mechanics Writing is free of spelling or grammatical errors and is concise.	*30 points*	*15 points*	*5 points*	

APPENDIX VII: Introduction to Research, Unit 3 Informational Interview Critique

Please watch the video "Dos and Don'ts of Informational Interviews"[6] and respond to the following questions:

1. Identify and describe 5 things that Don (the male student) did wrong in his informational interview.
2. Identify and describe 5 things that Sara (the female student) did correctly in her informational interview.

Student evaluation

Students were given full credit (100 points) if they made an honest effort to address the questions and were able to identify five criteria as to why the individuals had successful informational interviews or not.

[6] Syracuse University College of Law. (2012). *The Dos and Don'ts of Informational Interviews*. Retrieved from https://www.youtube.com/watch?v=ixbhtm8l0sI&feature=youtu.be

APPENDIX VIII: Introduction to Research, Unit 3 Informational Interview Critique

Conduct a 15-minute informational interview with someone engaged in research at UMBC. Interview can be conducted with a faculty member, research associate, postdoc, or graduate students.

Students have to meet the following deadlines:

July 30, 2018 – schedule the interview and submit the following via Blackboard:

- Name of person who you will interview
- Date, time, and location of the scheduled interview
- Three questions that you intend to ask during the interview

August 17, 2018 – after the interview, students will need to follow up with their interviewer and ask them to fill out an evaluation. Students are responsible for respectfully and professionally ensuring that the interviewer completes the evaluation. The evaluation is due by 5 pm on August 17, 2018 and the evaluation link is: https://goo.gl/forms/LUachoAvrSidM92s2

Student Evaluation:

This was a required assignment and students were given formative feedback on their 3 interview questions in advance of their interview. In the event that students had trouble finding an individual to interview, the Program staff connected students to individuals on campus via email.

After the interview, students were required to send the individual they interviewed with a link to provide feedback on their interview (see feedback form below). Once completed, students received this feedback about their interview.

Informational Interview Assessment (completed by the researcher who students interviewed)

This form is for the interviewee (faculty member, researcher, postdoc, graduate student) to provide feedback to the student who interviewed them. This information will be collected and shared with students individually.

If you have questions or concerns, please contact Dr. Laura Ott

Thank you for taking time to be interviewed by students in The BUILD Training Program and your continued support of STEM BUILD at UMBC!

Email address:
Name and Title:
Student name:

Please rate the student's informational interview on the following criteria:

Criterion	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
The student was prepared for their interview					
The student asked good questions					
The student was engaged during the interview					
The student was on-time and conducted themselves professionally					

Please provide comments on the strengths of the student's informational interview:

Please provide comments on ways the student can improve their informational interview skills:

APPENDIX IX: Introduction to Research, Unit 4 Mentoring Approaches and Conflict Resolution

Please watch the video entitled "Finding Your Research Home"[7] and read the following article:
Slaughter, G. R. (2006). Making the Most of Mentor Relationships. In *Beyond the Beakers: SMART Advice for Entering Graduate Programs in the Sciences and Engineering*. Baylor College of Medicine.

Mentoring Styles Activity[8]

Please read each of the following mentoring styles and identify the advantages and disadvantages of each. Then identify which type of mentoring style (hands on, hands off, or a mixture) is best for you?

1. This mentor is very hands-on and likes to be the primary mentor for their undergraduate researchers. They work directly with students much of the time and wants to know everything that goes on all the time. They set up weekly individual meetings and engages in frequent dialogue about the research.
   Please describe the advantages and disadvantages of this type of mentor.

2. This mentor is very famous and travels a great deal. Because of this, the researchers they advise have a formal system in which the senior researchers in the group act as mentors for newer students. They keep up to date on the progress of each student via frequent emails and meetings when in town.
   Please describe the advantages and disadvantages of this type of mentor.

3. This mentor is hands-off. They are around but likes to give students space to see how they handle independence. They typically have senior students informally mentor newer ones. This mentor meets with each student once a month and holds regular structured lab meetings.
   Please describe the advantages and disadvantages of this type of mentor.

4. Please briefly describe your ideal mentor. Will your mentor be hands on, hands off, or a little of both?

[7] NIH Office of Intramural Training and Education. (2014). *Finding Your Research Home*. Retrieved from https://www.youtube.com/watch?v=ho1Wm8eL6CY&feature=youtu.be
[8] These questions are from: Branchaw, J., Pfund, C., & Rediske, R. (2010). *Entering Research: A Facilitator's Manual. Workshops for Students Beginning Research in Science*. New York, NY: W.H. Freeman and Company (pps. 65-66).

Research Conflict Activity[9]

Please review the following scenarios and address how you would handle the situation.

1. Your mentor wants an experiment done this week, but you do not have time because of multiple exams. What do you do?
2. You have been working in the lab for 3 months and are not interested in the project any longer. How would you approach your mentor about this?
3. Someone in your lab gives you a new protocol that they say is better than the one given to you by your mentor. Which protocol do you use and why?
4. Your mentor expects you to know everything about your project and you are in over your head. The other students in the lab are no help. What do you do?
5. Jamal has been in his research group for almost three weeks and is disappointed with his project so far. Professor Stanley, Jamal's research mentor, described a molecular biology project that he would work on during his interview. However, his graduate student mentor, Roxanne, has not given him any molecular biology experiments, but instead tasks such as making media and growing bacteria. Other undergraduates in the lab seem to be doing things like cloning and sequencing genes. Jamal is getting frustrated, but doesn't want to complain or look ungrateful. What can he do?

   In your response, be sure to address the following:
   - To whom should Jamal go to discuss his frustration?
   - What strategies might he use to avoid appearing as though he is complaining?
   - How might having established specific goals and expectations with his mentor helped to avoid this situation?

6. Ashley, a sophomore majoring in chemistry, has found an undergraduate research position at the Center for NanoTechnology. She started a couple of weeks ago and is excited about her research project, which involves working on the development of an automatic gene synthesizer. However, Ashley doesn't really understand her project. She is a shy person and was completely overwhelmed at the first lab meeting. It was like nothing she had ever experienced and she understood very little of what was discussed. She won't take Introductory Biology until next year. At the meeting, she just nodded whenever they asked if she understood, because she didn't want to appear as if she was confused. Now she is terrified to talk to others on the research team for fear that they will realize how little she really understands. Her mentor Sam, a biomedical engineering graduate student, is really nice, but also very busy. He told her to ask questions when she didn't understand something, but he is always engrossed in his work and she doesn't want to interrupt him. She has to write a one-page summary of her research project for the undergraduate research seminar class by the end of the week, and has no idea where to begin. What should she do?

   In your response, please address the following:

[9] These questions are from: Branchaw, J., Pfund, C., & Rediske, R. (2010). *Entering Research: A Facilitator's Manual. Workshops for Students Beginning Research in Science*. New York, NY: W.H. Freeman and Company (pps. 88-90).

- Is there a way for Ashley to approach her mentor to ask questions that respects his busy schedule?
- Who else beside her mentor could Ashley turn to for help?
- What resources might she use to help herself better understand the research on her own?

Student Evaluation

Both the Mentoring Styles Activity and Research Conflict Activity are worth 100 points each. Students were awarded the points if they made an honest effort to answer the questions.
Formative feedback on the students' evaluation of the mentoring style and/or strategy for how to handle conflict was provided by the program staff.

Appendix X: Research Participation Items

Please check all the research activities you participated in **this past year (including LAST summer – 20XX)**. Choose all that apply.

Hands-on research activities with laboratory equipment in a class
Worked in a laboratory at UMBC
Worked in a laboratory at another college/university
Worked on research in a non-academic location (e.g. NIH, private corporation, industry, etc.)
Designed your own research experience or project
I did not participate in any research activities

Appendix XI: Research Self-Efficacy Items

These items assess your confidence in your research skills. Indicate the extent to which you feel confident you can successfully complete the following tasks. Please select the best answer on the scale from not at all confident to absolutely confident. (Scale is as follows: 1 = not at all confident, 2 = somewhat confident, 3 = moderately confident, 4 = very confident, 5 = absolutely confident)

Use technical science skills (use tools, instruments, and/or techniques)
Generate a research question to answer
Formulate a hypothesis about a research question
Determine which data/observations to collect
Design a strategy to collect data for a study Record
data collected during an experiment
Analyze data collected during an experiment
Create explanations for the results of the study
Use scientific literature and/or reports to guide research
Develop theories (integrate and coordinate results from multiple studies)
See connections between different areas of science and mathematics
Communicate scientific findings verbally
Communicate scientific findings through writing

These items are adapted from:
Chemers, et al. (2011). *Journal of Social Issues*, *67*(3), 469–491. Estrada, et al. (2011). *Journal of Educational Psychology*, *103*, 206–222.
Syed, et al. (2018). *Analyses of Social Issues and Public Policy*, *0*(0), 1–43.

Appendix XII: Science Identity Items

Belonging in Science. We want to understand how much you think that being a scientist is part of who you are. For the purpose of this study, when you see the word "scientist" it is intended to mean a professional undertaking research activities in their area of scientific study (e.g., a biologist or a research engineer). Please select the best answer on the scale from strongly disagree to strongly agree. (Scale is as follows: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree)

I have a strong sense of belonging to the community of scientists.
I derive great personal satisfaction from working on a team that is doing important research.
I have come to think of myself as a 'scientist.'
I feel like I belong in the field of science.

These items are adapted from:
Chemers, et al. (2011). *Journal of Social Issues*, *67*(3), 469–491.