

Building Research Skills through Being a Peer Reviewer

Dr. Lisa Benson, Clemson University

Lisa Benson is a Professor of Engineering and Science Education at Clemson University, and the Editor of the Journal of Engineering Education. Her research focuses on the interactions between student motivation and their learning experiences. Her projects focus on student perceptions, beliefs and attitudes towards becoming engineers and scientists, development of problem solving skills, self-regulated learning, and epistemic beliefs. She earned a B.S. in Bioengineering from the University of Vermont, and M.S. and Ph.D. in Bioengineering from Clemson University.

Prof. Rebecca A. Bates, Minnesota State University, Mankato

Rebecca A. Bates received the Ph.D. degree in electrical engineering from the University of Washington. She also received the M.T.S. degree from Harvard Divinity School. She is currently Professor and Chair of the Department of Integrated Engineering program at Minnesota State University, Mankato, home of the Iron Range, Twin Cities and Bell Engineering programs.

Dr. Karin Jensen, University of Illinois at Urbana - Champaign

Karin Jensen, Ph.D. is a Teaching Assistant Professor in bioengineering at the University of Illinois Urbana-Champaign. Her research interests include student mental health and wellness, engineering student career pathways, and engagement of engineering faculty in engineering education research. She was awarded a CAREER award from the National Science Foundation for her research on undergraduate mental health in engineering programs. Before joining UIUC she completed a post-doctoral fellowship at Sanofi Oncology in Cambridge, MA. She earned a bachelor's degree in biological engineering from Cornell University and a Ph.D. in biomedical engineering from the University of Virginia.

Dr. Gary Lichtenstein, Arizona State University

Gary Lichtenstein, Ed.D., Director of Program Effectiveness for the Entrepreneurial Mindset initiative at the Ira A. Fulton Schools of Engineering at Arizona State University. He is also and founder and principal of Quality Evaluation Designs, a firm specializing in research and evaluation for K-12 schools, universities, and government and non-profit organizations nationwide. He specializes in entrepreneurship education, research and evaluation methods, and STEM retention.

Kelsey Watts, Clemson University

Kelsey Watts is a fourth year Ph.D. student in Bioengineering at Clemson University. She is currently part of the EER Peer Review Training (PERT) research project team to investigate how EER scholars develop the schema for reviewing manuscripts and proposals. She is also developing Systems Biology outreach modules focused on computational skill development for Clemson's Emerging Scholars program.

Ms. Mia Ko, University of Illinois at Urbana - Champaign

Mia is a 4th year undergraduate student studying Bioengineering with a minor in Material Science and Engineering at the University of Illinois at Urbana Champaign. On campus, she actively participates as an Engineering Ambassador: encouraging younger students' interest in STEM related fields while changing the definition and conversation of what it means to be an engineer. Her research interests include motivation and STEM curriculum development and evaluation. She is very excited to be a part of this community and hopes to spark the interest of engineering education research within her peer groups and to return to education after industry experience.

Balsam Albayati

Building Research Skills Through Being a Peer Reviewer

Abstract

This paper describes a peer reviewer mentoring program called the Engineering Education Research Peer Review Training (EER PERT) project and serves as a pilot study on longitudinal effects on researchers' productivity and the impact of their work, differences in these factors for those who review journal manuscripts and those who review grant proposals, and what aspects of peer review training (knowledge, resources, collaborations, etc.) participants actually carry forward in their own research. Overall, the project seeks to investigate how engineering education research (EER) scholars develop skills and schema for reviewing scholarship, particularly in terms of developing constructive reviews that build expertise and advance knowledge. The *Journal of Engineering Education (JEE)* Mentored Reviewer Program constitutes the first phase of the EER PERT project. In this paper, we report on goals, structure and activities for the *JEE* Mentored Reviewer Program, pilot data from participants' applications and exit surveys that will inform the EER PERT project in terms of participants' developing skills and schema for reviewing and conducting EER, and provide initial suggestions from the training program that may benefit scholars new to EER.

Introduction

Reviewing scholarship in one's field is generally assumed to help build and strengthen research skills. We have seen this assumption evident anecdotally in conversations with peers and in messages from journals and peer review training programs. Yet there is scant empirical evidence supporting this assumption, or that explains the mechanisms for how one's research skills might be strengthened by reviewing manuscripts. To fill that gap, we examined the *JEE* Mentored Reviewer Program to identify information, structures, processes and practices that participants felt influenced their own knowledge of engineering education research and their confidence in their own research skills and productivity.

In this paper we describe the *JEE* Mentored Reviewer Program as the first phase of a larger project, the EER PERT project, and begin to address the exploratory research questions that will lay the groundwork for understanding how participants in a peer review training program develop reviewing skills and develop as scholars within the EER community. We first describe the background and purpose of the overall project, then provide details on the EER PERT project goals, structure and activities for the peer review program, and initial findings. In addition, we highlight the benefits of peer reviewing as a means of professional development for emerging engineering education scholars (i.e., post-docs and new faculty).

Background and Purpose

Reviewing manuscripts for publication is a critical means of building knowledge, forming professional identity as well as internalizing high standards of scientific research [1]. As a field, EER benefits from diverse perspectives aimed at improving engineering education and challenging existing models of professional formation of engineers. New faculty are often solicited to review journal manuscripts and grant proposals, but receive little to no formal training to develop their schema, or model, for conducting quality and constructive peer reviews

in their field. We have leveraged the knowledge and organizational structure of the first two rounds of the *JEE* Mentored Reviewer Program to create the EER PERT project. We anticipated that participants would experience benefits similar to those of the Publons Academy, a peer review training program. Responses from those participants included comments such as “This new knowledge of peer review has contributed to improving my own manuscripts as well: I can now think about the different types of article flaws from the perspective of a reviewer and author. Also, being critical of one’s own research leads to self-improvement” [2].

There is an implicit understanding in the research community that review is a service activity that helps develop scholarly work to the point of publication. However, ongoing discussions about the peer review process characterize it as “broken” and unnecessarily biased [3]. Peer review can be seen as a form of gatekeeping that reifies the “gladiatorial atmosphere” of academe, as observed by renowned entomologist and naturalist E.O. Wilson [4]. Wilson described an environment in which colleagues sometimes cheer each other’s accomplishments but often tear each other down and create factions. Other problems observed in the peer review process include lack of reviewer training, inconsistent and biased reviews, and a dearth of qualified reviewers [3]. Poor quality peer reviews can lead to poor quality scholarship; overly harsh, negative reviews can exclude diverse voices from the research community and stifle innovation [3].

When *JEE* launched the Mentored Reviewer Program in 2019, the goal was to make a concerted effort to promote constructive peer reviews [5]. With continuing rounds of the mentoring program and ongoing peer review workshops and training programs [6 - 9], EER journal editors have sought to reframe peer review as a constructive process that is inclusive and supportive of scholars at various stages of community participation. EER is a relatively new and interdisciplinary field, and as such, community members include new and emerging scholars and experienced scholars entering a new area of scholarship. This in particular makes us keenly aware of the need to be respectful in our reviews.

Taking a continuous improvement response and attitude towards building our community of scholars through peer review has direct implications for the approaches we take to reviewing scholarship and creating the scholarship itself. Just as we have shifted our response to qualitative research and to embrace calls for more diverse approaches in the publishing process [10], we need to embrace new perspectives and approaches to reviewing. We seek to frame the peer review process around mentoring and building up the EER community, to developing peer reviewing skills not only to become peer reviewers but also to become better scholars.

This project seeks to investigate how EER scholars develop skills and schema for reviewing scholarship, particularly in terms of developing constructive reviews that build expertise and advance knowledge. While previous efforts to improve peer review have focused on structural issues (e.g., open vs. closed reviews) [11], we are focusing on developing scholars’ skills using approaches that also build a sense of community and belonging for researchers new to EER.

EER PERT Project Goals

Building on the *JEE* Mentored Reviewer Program, the broader EER PERT project seeks to develop peer review training for EER scholars and conduct research on how individuals

develop mental models of the review process. The research goals of the project entail addressing the following research questions:

- *How do scholars develop schema for quality EER through collaboratively constructing peer reviews?*
- *How do reviewing skills in EER improve research skills?*

While we have already gained insights through the experiences and reflections from previous participants in the *JEE* Mentored Reviewer Program, we are exploring these questions more deeply by including a research component. A later phase of the EER PERT project will expand to include mentoring reviewers of EER grant proposals.

EER PERT Project Structure

Participants in the EER PERT project include mentees, mentors, and coaches. A diverse group of mentees are selected through a competitive application process. Mentors are experienced reviewers, and each mentor is grouped with two mentees to form triads. After completing program training, triads (two mentees and one mentor) work collaboratively on three separate manuscripts submitted to *JEE* over a period of about six months. Manuscripts are assigned by the journal's editorial board to identify best matches for the triad's expertise. Each triad member reviews the manuscript then discusses the manuscript with the triad. The triad then collaboratively drafts a review. After completing each review, triad members provide feedback to the project team (Fig. 1).

Coaches, who are typically former journal editors or associate editors, leaders in the EER community, or former mentors in the EER PERT project, are assigned four to five triads to support, similar to academic coaching models [12, 13]. Through periodic feedback surveys, the coaches monitor mentoring relationship quality and meet with triads as needed to ensure each is fulfilling program requirements. The current phase of the EER PERT project (the *JEE* Mentored Reviewer Program) includes 18 mentees, nine mentors and two coaches. Through funding from the National Science Foundation (NSF), all participants are incentivized through an honorarium, which they receive after completing the EER PERT project activities. Program participants receive a certificate of completion and a letter to their supervisor describing their achievements in the program. They are publicly recognized by the Editor in a *JEE* editorial once all in the cohort have completed the program, and are also recognized at the annual ASEE conference.

EER PERT Project Activities

The EER PERT project activities include recruitment, application review and participant selection, triad formation, training and orientation led by the project team, and manuscript reviewing, and feedback by the participants as shown in Figure 1.

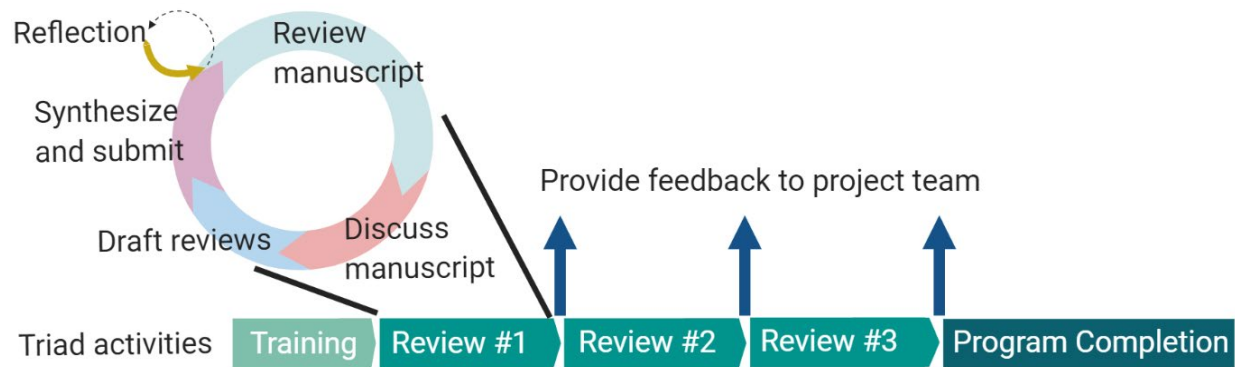


Figure 1. Flow chart of reviewing 3 journal manuscripts (Review #1, #2 and #3) and the process of scaffolded guidance within one review cycle: triads review and discuss manuscripts, draft reviews, then synthesize them into a single review and submit to the journal. Triad reflections are prompted through a feedback survey, which informs future iterations of PERT (project evaluation) and project research.

Recruitment: Focused recruitment for mentee applicants and mentor volunteers was designed to include diverse participants, particularly those who were not previously connected to the EER community. For example, recruitment efforts were conducted through the Historically Black Colleges and Universities (HBCU) STEM Undergraduate Success Research Center based at Morehouse College and the NSF Research Initiation in Engineering Formation (RIEF) Community network. This recruitment plan effectively supports the sustained engagement and integration of RIEF participants and diverse individuals in the EER community.

Application and Selection: Invitations for mentees to apply to the *JEE* Mentored Reviewer Program included a link to an online application. The application collected contact information and demographic data and had open-ended questions to determine each applicant's background and level of expertise. Questions requested information about demographics, Ph.D. concentration and year earned, relevant EER experience (e.g., publication and conference presentation history, reviewing history), confidence reviewing EER manuscripts, and the number of EER colleagues with whom they regularly interact. A single-item question asked applicants to identify their relationship to the EER community [14]. Applications are evaluated based on applicants' descriptions of their current position, EER and reviewing experience, motivation for seeking out this opportunity, and expectations for what they will gain from the experience. Mentees must have a baseline of experience to be able to contribute to reviews, and preference is given to "lone wolves" who do not have a home EER community of practice [15]. Mentors are nominated by journal editors through their consistently timely and constructive reviews or who have expressed a desire to give back to the EER community through mentoring. Mentors are also recruited through personal and professional networks such as the Educational Research and Methods (ERM) division of the American Society for Engineering Education (ASEE), the EER journal editor roundtable (an informal network of journal editors in our field), and the EER PERT advisory board. Mentors are asked to complete an application similar to the mentee application, with additional questions related to mentoring experience and interest. The selection of mentees and mentors is completed by project team members who individually review and rank

applicants, then meet to discuss and make final selections. The team takes notes on reasons for individual rankings, which assists with triad formation and also helps in crafting messages to those who were not selected. These individual messages include suggestions for resources to strengthen the individual's reviewing and EER skills and other ways to connect with the EER community, i.e., through relevant divisions of ASEE, the ASEE Commission on Diversity, Equity and Inclusivity (CDEI), other EER societies such as SEFI, and regional conferences. We believe this is an important step in ensuring an inclusive application process while enabling the team to select the most appropriate individuals as mentees.

Triad Formation: Information about areas of expertise are extracted from the applications of selected mentees and organized into a spreadsheet. Mentors and mentees are grouped based on overlapping expertise in terms of research methods, theory and contexts. Consideration is also given to geographic regions to facilitate scheduling meetings, as participants are from all over the globe. Mentors and mentees are introduced to each other via an email from the project team, which includes links and instructions for the next steps (training and orientation sessions).

Training and Orientation: Multiple forms of training are conducted to accommodate those in diverse locations and with diverse types of academic appointments. Online orientation and training materials are provided as both synchronous and asynchronous sessions, based on prior success with this mode of delivery in the *JEE* Mentored Reviewer Program. Three asynchronous sessions were developed to discuss 1) the goals and structure of the *JEE* Mentored Reviewer Program, 2) the journal (*JEE*) as a publication and its review process, and 3) best practices in peer reviewing (i.e., organization, quality considerations, tips for writing reviews). Triads then attend a synchronous session together, and after an icebreaker activity and a brief overview of the program, they conduct a mock review of a short, published manuscript together as a triad during the session. The mock review makes use of a Structured Peer Review form, which helps triads organize their reviews (strengths, weaknesses and recommendations) and provides the team with insights on what participants are taking into consideration as they conduct their review. (The Structured Peer Review form, which was developed by the project team, is shown in Figure 2.) The session concludes with sharing ideas for writing constructive reviews and instructions for how to access and share manuscripts as they are assigned to triads by members of the journal's editorial board. Workshops materials are posted on the project website [16] so that others in the community can adapt them for their own mentored reviewer experience.

Manuscript Assignment and Review: A list of the triad names, affiliations, and areas of expertise are shared with members of the *JEE* Editorial Board so that they can assign manuscripts to triads. The first manuscript is assigned to the mentor, who then shares the manuscript with their mentees. Reviewing manuscripts begins with individual reviews using the Structured Peer Review form as a starting point. This seems to help the participants organize their thoughts about the manuscripts and helps coordinate collaborative review process. After individuals draft reviews, they share and discuss them within their triads. Triads meet online to formulate and write reviews collaboratively, and to discuss the review process in general. Triad members take turns leading reviews so each gains experience with the full process of writing, revising, and submitting reviews; the lead reviewer in each round is responsible for documenting and leading reflections on the triad's review process and for submitting the review for the triad.

Structured Peer Review Form

Greetings *JEE* Mentored Review Program Mentee or Mentor,
 Use this template to complete Structured Peer Reviews (SPRs). SPRs are a way to begin thinking about a manuscript review. Your responses may be first impressions that may change; there are no right or wrong answers. We will not share these responses with your triads, but feel free to use them as a start to your discussions.

Thank you,
 The *JEE* Mentored Review Program Research & Evaluation Team

Name
 Email address
 Triad
 Manuscript number

- What are three notable strengths of this manuscript?
- What are three notable weaknesses of this manuscript?
- Please summarize up to three recommendations you would make to the authors to improve the manuscript.
- What would be your recommendation to the editor?
 - Accept as is
 - Minor Revision (revise and resubmit; no need for another round of reviews)
 - Major Revision (revise and resubmit; needs another round of reviews)
 - Reject
- Explain the basis of your recommendation to the editor in 200 words or less.

Figure 2. Guidance and questions made available to mentees and mentors in the Structured Peer Review form.

Feedback: Through short surveys completed after each triad completes a manuscript review, feedback is gathered by coaches from their assigned triads. Surveys are completed separately by mentors and mentees, and organized similar to a SWOT (strengths, weaknesses, opportunities and threats) analysis. Follow-up virtual meetings with coaches are conducted as needed based on survey responses.

EER PERT Research Activities

The project explores the following research questions: *How do scholars develop schema and skills for providing feedback in EER peer reviews? To what extent are disciplinary conventions related to manuscript quality and value similar or different across EER contexts? Is there a tacit, shared EER schema assessing quality and value of EER manuscripts?*

Research data include applications, structured peer reviews (using the form shown in Figure 2), think-aloud protocols, mentor and mentee interviews, and exit surveys. The Structured Peer Review form is a template that mentors and mentees complete as a first pass into reviewing a manuscript. Participants note three strengths, three weaknesses, their recommendation to the Associate Editor, and the factors that most weighed in the decision. Responses reflect the criteria reviewers use when evaluating a manuscript and these criteria reflect the mental schema reviewers bring to the process. Revealing the schema can improve professional development and

help identify the basis upon which reviewer recommendations are made. Revealing participants' schemas for reviewing scholarship is the aim in all data collected, including interviews and think-aloud protocols.

In addition to research questions, the project administers surveys and conducts focus groups to gather mentee and mentor perspectives for continuous program improvement.

Early Insights and Experiences from EER PERT

Review of Applications: We first examined responses to questions on the mentee program application from the first round of the *JEE* Mentored Reviewer Program in 2019. In response to the question “Why are you interested in learning more about the review process?,” the majority of mentee applicants (25 out of 34) indicated that they were seeking to strengthen their own research skills and apply what they learn to their own research. Typical responses identified improving the quality of their writing, creativity, and depth of knowledge. Most stated that feedback they received on their own work, particularly constructive feedback, improves the quality of their research and writing. Some applicants cited the desire to become more familiar with terminology and research methods that are new to them as education researchers.

The first two rounds of the program drew 80 applications from 16 countries, demonstrating the global demand for peer review training in EER. Feedback from the initial program offerings indicated positive outcomes of expanded expertise, a greater understanding of research quality, and shifting the dominant (negative) discourses about peer review to a more positive view of knowledge production and publishing. Mentees in the first iteration of the program shared that the program was instrumental in developing identities as engineering education researchers. The program also provided a welcoming community to facilitate participants' active engagement in the community. The emphasis on collegial and constructive review fosters a culture of mentorship that strengthens the field [20].

Exit Survey: To gain insight into how the peer review process influenced participants' own research skills, an exit survey was designed based on the cognitive apprenticeship model. The Exit Survey is given to participants who complete the program to evaluate the effectiveness of the program structure. Cognitive apprenticeship theory grew out of trade apprenticeships where a novice learns a trade by working under experts. Its purpose is for learners to acquire knowledge through carefully sequenced authentic learning activities that allow them to develop expertise within a community of practice. Cognitive apprenticeship models have been used as frameworks for evaluating research assistantship [17] and apprenticeship [12, 18] programs, as well as engineering faculty being mentored in EER through the NSF RIEF program [19]; thus it is appropriate for examining how scholars develop skills and schema for reviewing EER scholarship. Using the four model dimensions of content (types of knowledge needed for expertise), sequencing (keys to ordering learning activities), and method (ways to promote the development of expertise), and sociology (social characteristics of the learning environment) [20], participants are asked to describe their previous experiences and perceptions of EER as well as whether or not their expectations prior to the program were met. Mentees are then asked about the effects of the program itself on both developing skills and confidence as a reviewer and on better integrating themselves into the EER community. Mentors are asked to rate the development of their mentoring abilities and growth as a researcher. Complementing these questions, participants are able to make additional comments about their experiences and

significant takeaways of the program and interactions with their mentor or mentee/co-mentee.

Of the 18 mentees surveyed from the Fall 2020 iteration of the *JEE* Mentored Reviewer Program, 11 filled out the exit survey for a ~61% response rate. We were specifically interested in the following questions:

- What did the mentees gain from being part of the JEE mentoring program?
- How can the mentoring program continue to improve?

Mentee Exit Survey Results Summary: Reviewing Skills: All participants surveyed (11/11) indicated that the program helped improve their reviewing skills moderately or to a great extent (Fig. 3). The majority (9/11) believed that it increased their understanding of the EER peer review process and their confidence to write an EER review moderately or to a great extent (Fig. 3). Participants reported this increased confidence in reviewing skills was due to a better understanding of how to provide constructive criticism that is useful to authors and editors. Comments from two participants include:

It allowed me an opportunity to look critically at and formulate manuscript reviews in a space where it was hard to fail (because the rest of the team was there to support me).

and

I believe I am better able to structure a review so that it is useful to the editor and the author, as well as express myself in the review.

In an open-ended item, 6/10 respondents mentioned as their greatest take-away that they learned better ways to provide constructive criticism to authors/editors.

Research Skills: The majority of respondents (8/11) indicated that the program improved their confidence to conduct EER research (Fig. 3). They cited gaining a better understanding of how others framed and perceived arguments/evidence. Participants reported that they learned new ways to present data as some of the common gains to their research skills. The majority (9/11) felt that they would be more confident submitting an EER manuscript (Fig. 3):

[The program] improved my ability to analyze the key arguments and logic in a given manuscript, thereby improving how I can frame my own arguments.

and

I have a greater understanding of the subtleties of what makes great research, compared to so-so research.

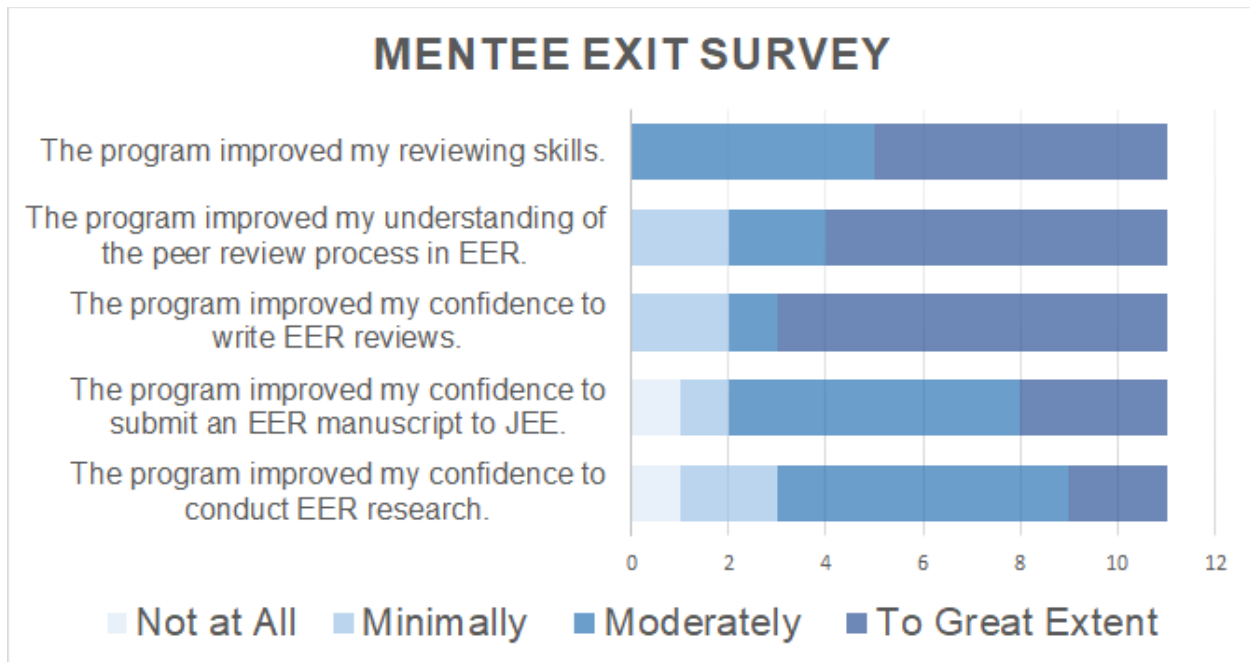


Figure 3. Mentees in a previous round of the *JEE* Mentored Reviewer Program were surveyed after completing the program and asked about its effect on their reviewing and researching skills.

Relationship to Community: Participants were asked what their relationship to the EER community was pre and post completion of the mentoring program using the visualization shown in Figure 4. Prior to completing the program, the median of the participant ratings fell within option 2 with little (~15%) overlap. Upon completion of the program, the median of the participant ratings fell within option 3 with ~50% overlap. The majority of participants (7/11) felt that program helped them expand their relationship within the EER community. The average perceived relationship of the overlap to each participant's relationship to the EER community increased from 40% at the beginning of the program to 62% at the end. The participants cited meeting new colleagues as part of the program and gaining a better understanding of the EER space beyond their discipline as the greatest sources of growth to their relationship within the EER community. Comments included:

To feel part of the reviewing process, and to meet other people in the field (not only outside of my institution but also my country and continent) has been immensely positive.

and

Beforehand, I felt mostly connected to engineering education within my discipline. I now feel more comfortable in the general EER space.

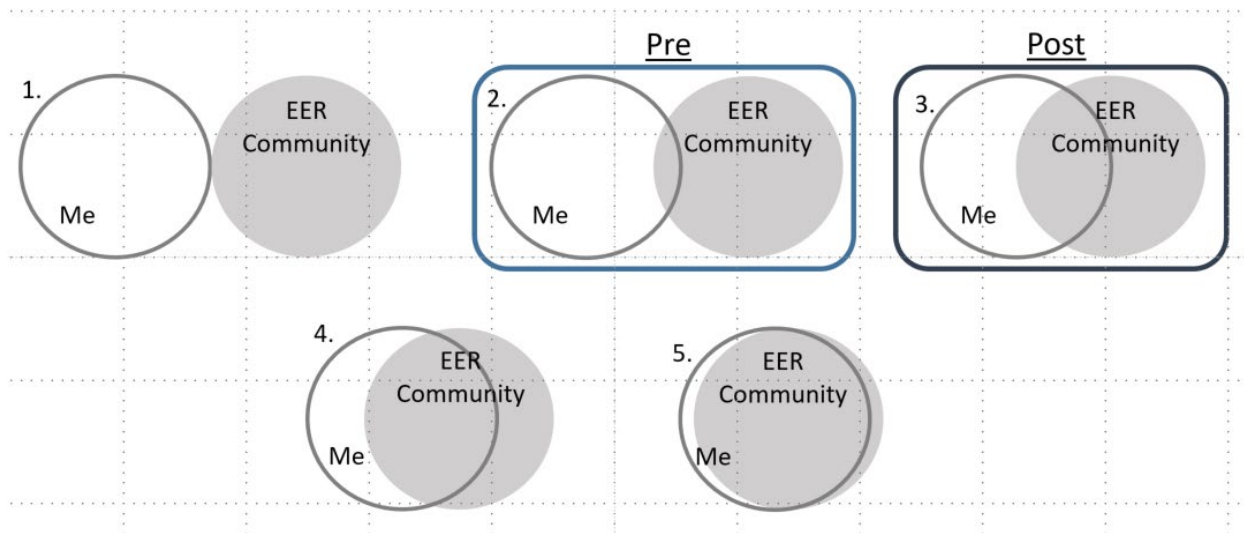


Figure 4. Single-item question on the program application and on the exit survey for the *JEE* Mentored Reviewer Program. Average responses on the application (“Pre”) and exit survey (“Post”) are shown in the figure.

Overall Feedback on the Program: A majority of the mentees (9/11) expressed that their expectations were met “to a great extent.” All mentees indicated that their time spent in the program activities was valuable. In response to the question about changes as a result from program participation, sample responses include “feel more connected with EER community.” This corresponds with results observed in the single-item question shown in Figure 4. Participants provided feedback for improving the program, such as:

I feel more aware and familiar with the process but I'm not much more confident as I would like more practice/experience with the mentor as a guide since the manuscripts are so diverse. Don't feel had enough experience with varied methodologies, writing style, examining fidelity between research questions and methods or data presented.

This indicates a need for the program to be more flexible in terms of the number of manuscripts each triad completes. In future rounds of the program, we plan to emphasize to participants that they can continue in their mentoring relationship beyond three manuscripts.

The triad structure, where two mentees work with one mentor, was a noted benefit from program participants. For example, one participant shared:

The single best aspect of doing the programme has been working in a team of three. It made the experience less about a flow of knowledge from mentor to mentee, and more about a genuine three-way exchange between all of us that was somehow more than the sum of its parts.

Discussion

Drawing from a peer review mentoring program developed by *JEE*, the EER PERT project is expanding and defining a training framework wherein researchers are mentored by an experienced reviewer to write a series of reviews as a team. Feedback from the initial program

offering indicated positive outcomes of expanded expertise, a greater understanding of research quality, and shifting the dominant (negative) discourses about peer review to a more positive view of knowledge production and publishing. Ultimately, the project aims to improve EER scholarship, which in turn could promote its adoption in engineering classrooms, and to strengthen the culture in EER through constructive and inclusive peer review [22].

Implications for Individual Scholars: Although the focus of this paper is on the mentoring program itself as a mechanism to provide professional development opportunities, it is not possible to include in the program all scholars who would benefit from it. An inclusive extension to the program is a set of organized resources available for all reviewers on the “Resources for Reviewers” page on the EER PERT website [16]. These include an excellent editorial on equity and inclusivity in reviewing [10] and quality considerations [23, 24], among others, as well as tools like the structured peer review guidelines (Fig. 2). Even if individuals are not participating in EER PERT, there are experiences that those within and on the margins of the EER community can generate to build their reviewing and research skills, and to expand their EER expertise. These experiences can use EER PERT resources in critically reviewing published works with an eye on how to improve or expand them. Individuals who are new to the community can seek out peer networks and establish writing groups in which they can exchange internal reviews among members. Pairs of potential mentees can seek out mentors from the community to create their own triads, which have the benefit of peer support between mentees as well as expertise from a mentor.

Implications for the EER Community: Through ongoing program evaluation and research, the EER PERT project seeks to better understand how individuals build EER skills through reviewing. This will help reframe peer reviewing not simply as a service activity but more so as a professional development activity. This is a story worth telling: all previous participants who completed exit surveys indicated that they would recommend this program to a friend, and the majority had their expectations met to a great extent.

Reframing Peer Review as Professional Development: The model developed in this project of formally recognizing and supporting the work that reviewers and mentors do, and recognizing the contributions these individuals make to EER scholarship, could be leveraged by EER programs and centers as well as other disciplines. Letters acknowledging program completion sent from the project coordinator to the deans and supervisors of mentors, mentees and coaches can raise the profile of reviewing from a form of service to a recognized form of professional development. Understanding how reviewers develop mental models to evaluate EER scholarship will further help editors and funding agencies cultivate and provide quality reviews that promote inclusion and foster innovation. We anticipate that our findings will change the culture around peer review to one of mentoring rather than gatekeeping, and of professional development as well as service.

Adapting EER PERT in the EER Community: We have developed this formal program with a structure and goals, and key learning experiences from participants. Our findings indicate that the triad structure (one mentor and two mentees) may be beneficial to other academic training programs and could be implemented by initiatives of interested mentees. We are hopeful that other EER journals will adapt this program and individuals will make use of the materials developed as part of EER PERT. Although setting up the mentoring program, selecting and orienting the participants and assigning manuscripts to triads is a limitation in terms of the time

and effort involved with implementing such a program, it provides benefits such as more timely reviews and building the pool of individuals who are trained and can complete reviews on their own in the future. This could serve to widely develop the EER community's practice of giving deep, constructive criticism on scholarly work (journal publications, conference papers and presentations, and grant proposals, as well as student-generated theses and dissertations). While such critiques can be challenging to generate and receive, as constructive and inclusive practices become the norm in the EER community, we will still be able to maintain a sense of connection and camaraderie that will sustain and grow our community.

Expanding the EER Community: The EER PERT project serves not only as a call for new engineering educators and education researchers to learn new skills right now, but also as a call to the EER community to consider how we continue to develop as a growing field. Mentored training opportunities in reviewing EER scholarship may increase participation of engineering faculty in the EER community (e.g., through applying to the NSF RIEF program). Mentees expressed the advantage of learning from both their mentor and co-mentees, and sharing different approaches to peer review. Additionally, since each triad works collaboratively on three or more manuscripts over several six months, triad members have the opportunity to build relationships and learn from the diverse expertise and perspective that each member of the triad brings.

Future Work

The *JEE* Mentored Reviewer Program is currently in its third offering, and the current offering constitutes the first phase of the NSF-funded EER PERT project. *JEE* plans to continue to offer its Mentored Reviewer Program in two separate cohorts each year. Program improvements will be implemented from ongoing program assessments and research findings from the EER PERT project. The EER PERT project will continue to expand in terms of the EER journals included and to expand to grant proposal reviews. Other future work relates to research activities and exploring sustainable models for the EER PERT project beyond the life of the NSF grant currently supporting it.

Continuous Improvement of EER PERT Activities: Most mentees in prior rounds of the *JEE* Mentored Reviewer Program indicated that their level of confidence to conduct EER was minimally impacted by their participation. One possible reason is that participants identified themselves as having moderate-extensive background in EER from the beginning, so there was not much room for increasing their EER skills. In the current round of the program, we are being more deliberate in including participants with a wide range of EER expertise to allow for growth in multiple dimensions of their participation (reviewing skills, research skills and professional network).

Expansion beyond the *Journal of Engineering Education*: The first phase of the EER PERT project entailed a round of the *JEE* Mentored Reviewer Program. We further plan to offer targeted training that incorporates findings from our research on how peer review strengthens an individual's research skills in collaboration with other EER journal editors. To support scholars who are not currently participating in the program and editors who would like to initiate a similar program, the *JEE* Mentored Reviewer resources are available on a public website [16]. We encourage scholars in this situation to seek out mentors and editors to provide a structure that allows for mentored development.

Expansion to Grant Proposal Reviews: In the final phase (Year 2) of the EER PERT project, the review cycle shown in Figure 1 will entail reviewing grant proposals rather than journal manuscripts. The scaffolded guidance will remain but the reflection process and feedback to coaches will culminate with mock virtual review panels. These mock review panels will involve three to four triads, led by coaches, to prepare mentees for participating in live review panels. Mentors and coaches will be former NSF program officers and review panel leaders, or former mentors in the EER PERT project with proposal review experience. Mentors and coaches will be recruited in similar ways as for those in the journal manuscript review phase.

Future research: The triad mentoring structure has been expanded to include coaches. The coach role was added after feedback from the first two rounds of the *JEE* Mentored Reviewer Program indicated that there are challenges that some triads experience that would benefit from discussion and guidance from a third party. At this time, we are just beginning our activities with coaches, and future research will focus on both their effects on the program and the program's influence on the coaches. As the program expands to include grant proposal review, we will be exploring the similarities and differences between schema development for manuscript and grant proposal review.

Sustaining the EER PERT Project: Beyond the completion of the NSF funding period, we will be exploring other ways to support this as an ongoing activity in the EER community. Possible models include fee-based programs: in-person or online workshops, and online, asynchronous training developed and refined through this project. The target audience for these programs would be early career researchers, post-doctoral researchers, and graduate students who are within a year of graduation. Industry and institution-funded scholarships could support broad participation. For post-docs, these trainings could serve as part of a post-doc mentoring plan within NSF-funded projects. Workshops and subsequent training sequences could mimic the mentored reviewer structure established in the EER PERT project, depending on the findings from our study, in which mentor and coach stipends are covered through program fees.

While training materials will be broadly available, targeted training that incorporates findings from our research on how manuscript and proposal review strengthens an individual's research skills will add value and content to these trainings, ensuring they will be high quality professional development experiences. We anticipate that deans and program directors will seek out these workshops and training opportunities to increase the likelihood of professional success of early career faculty and to strengthen the research base in the EER community. Our findings on aspects of schema development that align with strengthening research proposal writing and manuscript writing skills for the participants can help promote the fee-based workshops. These workshops will be relatively low cost if offered virtually, which will also increase accessibility for those with limited resources.

Conclusion

Training emerging EER scholars in constructive reviewing of EER scholarship will strengthen and diversify the EER community. The proposed approach to building pools of qualified reviewers developed through this project will benefit "lone wolf" EER scholars who are not members of an engineering education department, program or center and who do not have ready access to a community of practice in EER to develop their scholarship reviewing skills. Further, the training model and resources will promote growing and diversifying the EER community by breaking down the barrier to engagement in the community caused by a lack of access to EER

scholarship for those without formal training in EER methods. There is global demand for this type of training as seen by the over 80 applications from 16 countries for the pilot program. Mentored training opportunities in reviewing EER scholarship may also increase participation of engineering faculty in the EER community. The model developed in this project of formally recognizing and supporting the work that reviewers and mentors do, and recognizing the contributions these individuals make to EER scholarship, could be leveraged by other disciplines and EER programs and centers to raise the profile of this form of service. Understanding how reviewers develop mental models to evaluate EER scholarship will further help editors and funding agencies provide quality reviews that promote inclusion and foster innovation. Ultimately, we anticipate that our findings will create a more positive culture around peer review.

Acknowledgments: This material is based upon work supported by the National Science Foundation under Grant No. 2037807. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors wish to thank the program participants for sharing their experiences and the mentors and coaches who support the program. We thank EER PERT project advisory board members Rocio Chavela, Bev Watford and Darryl Williams for providing guidance on the development of this project.

References:

- [1] National Research Council, *Scientific Research in Education*. Washington, D.C.: National Academies Press, 2002.
- [2] Publons. “Starting out in peer review: putting skills into practice.” August 20, 2018. Retrieved from <https://publons.com/blog/starting-out-in-peer-review-putting-skills-into-practice/>
- [3] A. E. Carroll, “Peer Review: The Worst Way to Judge Research, Except for All the Others.” NY Times, November 6, 2018. Retrieved from <https://nyti.ms/2yRcClr>.
- [4] C. Tyson, “E.O. Wilson on the Next Big Thing.” *Chronicle of Higher Education*, May 7, 2019. Retrieved from https://www.chronicle.com/article/EO-Wilson-on-the-Next-Big/246257?utm_source=at&utm_medium=en&cid=at
- [5] L. Benson, “Reflecting, Rebooting, Reviewing,” *Journal of Engineering Education*, vol. 108, no. 3, p. 311 - 312. 2019. <https://doi.org/10.1002/jee.20288>
- [6] K. Edström, J. Bernhard, M. van den Bogaard, L. Benson, C. Finelli, S. Chance, S. and R. Lyng, “Reviewers, reviewers, reviewers!” Workshop conducted at the SEFI 2018 Conference, Copenhagen, Denmark, September 20, 2018.
- [7] L. Benson, A. Carberry, J. Case, K. Edström, C. Finelli, K. Le Roux, J. Swart, J. and M. van den Bogaard, “Unpacking the Writing and Publishing Process for Engineering Education Researchers,” Workshop conducted at the Research in Engineering Education Symposium, Cape Town, South Africa, July 10, 2019.
- [8] K. Edström, L. Benson, J. Mitchell, J. Bernhard, M. van den Bogaard, C. Finelli, N. Kellam, M. Lee, S. Lord, D. Rover, H. Saliyah-Hassane, and S. Zappe, “Review Unto Others As You Would Have Others Review Unto You,” Workshop conducted at the Frontiers in Education Conference (virtual), October 24, 2020.
- [9] L. Benson, N. Kellam, and S. Zappe, “Growing our Research Community, One Reviewer at a Time,” Workshop to be conducted at the 2021 ASEE Annual Conference and Exposition, Long Beach, CA, July 26, 2021.

- [10] B.C. Coley, D.R. Simmons, and S.M. Lord, "Dissolving the margins: LEARNING INTO an antiracist review process." *Journal of Engineering Education*, vol. 110, no. 1, pp. 8-14. 2021. <https://doi.org/10.1002/jee.20375>
- [11] L. Bornmann, M. Wolf & H.D. Daniel. "Closed Versus Open Reviewing of Journal Manuscripts: How Far Do Comments Differ in Language Use?," *Scientometrics*, Springer; Akadémiai Kiadó, vol. 91(3), pages 843-856, June, 2012.
- [12] P. Fazel, "Teacher-Coach-Student Coaching Model a Vehicle to Improve Efficiency of Adult Institution," *Procedia - Social and Behavioral Sciences*, Science Direct, 2013. Retrieved from <https://www.sciencedirect.com/science/article/pii/S187704281303694X>.
- [13] B. Neufeld & D. Roper, *Coaching: A strategy for developing instructional capacity – promises and practicalities*. Washington, DC: Aspen, 2003.
- [14] M.M. McDonald, V. Zeigler-Hill, J.K. Vrabel, and M. Escobar, "A single-item measure for assessing STEM identity." *Frontiers in Education Conference*, vol.4, no. 78., pp. 1-15, 2019.
- [15] D. M. Riley, J. Karlin, J. L. Pratt & S. M. Matos, "Building Social Infrastructure for Achieving Change at Scale" *Proceedings of the ASEE Annual Conference and Exposition*, Paper ID #19202, June 2017.
- [16] *Journal of Engineering Education*. "JEE Mentored Reviewer Program," 2020. Retrieved from <https://sites.google.com/view/jee-mentored-reviewers/mentored-reviewer-program>.
- [17] M. A. Maher, J. A. Gilmore, D. F. Feldon & T. E. Davis, "Cognitive Apprenticeship and the Supervision of Science and Engineering Research Assistants," *Journal of Research Practice*, vol. 9, no. 2, 2013.
- [18] I. Sasson, "Participation in Research Apprenticeship Program: Issues Related to Career Choice in STEM," *International Journal of Science and Mathematics Education*, vol. 17, no. 3, pp. 467–482, Mar. 2019.
- [19] J. F. Mirabelli, A. J. Barlow, M. Ko, K. J. Cross & K. J. Jensen. "Work in Progress: A Qualitative Study of Mentorship, Training Needs, and Community for New Engineering Education Researchers" *Proceedings of the ASEE Annual Conference and Exposition*, Paper ID # 29273, June 2020.
- [20] A. Holum, C. Allan & J. S. Brown, "Cognitive Apprenticeship: Making Thinking Visible," *American Educator*, vol. 15, no. Winter, pp. 1–18, 1991.
- [21] K. Jensen, I. Direito, M. Polmear, T. Hattingh, and M. Klassen, "Peer review as developmental: Exploring the ripple effects of the JEE Mentored Reviewer Program," *Journal of Engineering Education*, vol. 110, no 1, pp. 15-18, 2021. <https://doi.org/10.1002/jee.20376>
- [22] Nature Editorial: "Peer review should be an honest, but collegial, conversation," *Nature*, 582, 314, June 17, 2020. doi: <https://doi.org/10.1038/d41586-020-01622-z> Retrieved from <https://www.nature.com/articles/d41586-020-01622-z>
- [23] J. Walther, N. W. Sochacka & N. N. Kellam, "Quality in Interpretive Engineering Education Research: Reflections on an Example Study," *Journal of Engineering Education*, vol. 102, no. 4, pp. 626–659, 2014. doi.org/10.1002/jee.20029
- [24] N.W. Sochacka, J. Walther & A. L. Pawley, "Ethical Validation: Reframing Research Ethics in Engineering Education Research To Improve Research Quality," *Journal of Engineering Education*, 107(3): 362-379, 2018. doi:10.1002/jee.20222