AC 2011-826: REALISTIC OPEN-ENDED ENGINEERING PROBLEM SOLVING AS SITES FOR POSTDOCTORAL RESEARCHER TRAINING IN COURSE INSTRUCTION AND DEVELOPMENT

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Realistic Open-Ended Engineering Problem Solving as Sites for Postdoctoral Researcher Training in Course Instruction and Development

Abstract

Traditional roles of postdoctoral researchers often involve scholarly activities that are focused on research and grant writing. Seldom do PRs receive training on activities pertaining to curriculum and instruction – topics that are important if these PRs intend to pursue a career in academia. Typically PRs enter their faculty roles without teaching experience or the knowledge and skills necessary for course development. It is essential for PRs to acquire the needed knowledge and skills during their training to ease their transition to becoming a productive faculty member.

This paper explores the experiences and challenges faced by a PR who had the chance to engage in instructional activities. She is a member of a team responsible for teaching assistant professional development with mathematical modeling problems taught in a first-year engineering program. Model-Eliciting Activity TA professional development was the PR’s training site.

I. Introduction

A career in academia continues to be the choice of many doctoral degree graduates. What attracts many to academia is job security, flexible working hours, choice of research and teaching topics, and opportunities to engage in professional memberships in societies dedicated to leadership and management. Once one’s area of expertise is mature, the academic career opens opportunities for contributing to the larger research community. This includes engaging as an editor and reviewer of academic publications and grants applications. Other rewarding roles include being a mentor for new faculty, graduate, and undergraduate students. Lastly, some faculty venture into industrial partnerships by providing consultation to companies, while others start their own companies.

Upon graduation, students assume they will possess the innate ability to impart the knowledge they have gained to their students. This is seldom the case. Often, those who receive training on teaching and curriculum instruction and development are those who are directly involved with education. Upon attaining an academic position, engineering graduates are expected to teach in a classroom setting, though most were only trained to do research in their area of expertise during their doctoral studies. They often experience transition shocks from being a student to becoming a professional faculty member.

While the pathway to developing a solid research program is typically clear, the road to teaching excellence provides challenges that are unique to an individual instructor at any stage of an academic’s career. Teaching is best learned through hands-on experiences as opposed to instruction delivered via lectures or textbooks. However, studies show that most faculty is not trained to be teachers. At most, new faculty received training on pedagogy and curriculum development with no practical experience.

Graduate schools offer resources and teaching awards to encourage teaching. Some graduate students receive teaching certificates and accept roles as teaching assistants. However, a large
portion of most graduate students’ time is devoted to research. Because graduate students have several milestones that they have to complete during their degree programs, (e.g. qualifying and preliminary examinations), their engagement in teaching is minimized. Similar neglect to teaching is also experienced by post-doctoral researchers (PRs). During the post-doctoral training period, PRs engage in research, dissemination, grant writing, mentorship of younger researchers, and, to a lesser extent, teaching. While resources are available for PRs to improve their teaching as provided by professional development centers at universities, most of the training provided is offered in the form of seminars and workshops, in which PRs do not experience hands-on teaching. Only upon becoming a full faculty member does one typically engage in actual teaching and curriculum and instruction development. There is a need for training sites for PRs in which they can see teaching techniques modeled and they can gain develop their teaching skills through hands-on experience.

This paper explores how Model-Eliciting-Activities (MEAs), as an example of a new research-based pedagogy or course innovation, could be used to prepare those who are interested in a career in academia for classroom instruction through a PR experience in teaching assistant (TA) training. Traditional means of learning classroom instruction techniques (e.g. giving a few lectures for a course and homework) are insufficient because they do not introduce PRs to new pedagogies or ways of new ways of thinking about instruction and curriculum. These methods also do not introduce PRs to real-world engineering problem solving in the classroom. If one wants to become a faculty member who teaches well in addition to conducting research, the use of realistic open-ended engineering problems with embedded mathematical modeling provides an opportunity to gain teaching skills.

II. Setting for Post-Doctoral Experience

A. First-Year Course

The first-year engineering (FYE) program at Purdue University serves as a launching pad for undergraduate students in pursuit of an engineering degree. One of the main objectives of the FYE program is to provide first-year students with a foundation in engineering problem solving which is adaptive to the engineering community. The curriculum reform of the FYE program shifted from computer tools to a problem solving focus involving mathematical modeling. What sets the first-year engineering courses apart from traditional engineering classes is instruction that requires students to not only solve technical problems, but apply and adapt engineering concepts in mathematical models while developing professional skills - the ability to work in teams and translate mathematical models into a written procedure.

B. Model-Eliciting-Activities (MEA)

Typical engineering classes are exam-based, project-based, or a combination of these. Seldom do engineering classes provide sufficient activities that involve real-world problem solving. Therefore, there is a need for engineering classrooms to increase students’ exposure in such activities. One method for fulfilling the FYE program learning objectives is Model-Eliciting-Activities (MEAs). MEAs are designed to bring engineering contexts and content into the first-year classrooms, where students are introduced to open-ended problem solving via mathematical
modeling and team work inside and outside of the classroom. MEAs require students to develop a logical algorithmic problem solving strategy to an engineering problem that has a certain degree of open-endedness. That is, students are required to translate an engineering problem into a mathematical model.

There are many challenges associated with implementing MEAs. These include class size and demographics, limited in-class time, students’ perceptions of learning through open-ended problem solving, and the training of a large number of teaching assistants involved in the course. Since the Fall of 2002, revisions to the MEA instruction and assessment have been dynamic. MEA reformers – those involved in MEA curriculum reformation - have continuously updated their understanding of the students, faculty, and teaching assistants (TAs) involved in MEA implementation. The universality and dynamic nature of MEAs makes it a suitable site for PR training (or graduate student training) in curriculum instruction and development.

In the Fall of 2010, the PR was responsible for training TAs to implement two MEAs: 1) Travel Mode Choice MEA – which requires students to create a procedure to predict students’ choice of transportation to campus as either walking, taking the bus, or driving; and 2) NanoRoughness MEA – which requires students to create a procedure to quantify roughness given atomic-force-microscopy (AFM) images.

C. Teaching Assistants (TAs)

Teaching assistants (TAs) involved in the MEA training in Fall 2010 consisted of both graduate teaching assistants (GTAs) (n = 5) and non first-year undergraduate students (n = 79), who were called peer teachers. These TAs could be categorized based on their experience with MEAs. Experienced TAs are those who taught with MEAs at least once. These TAs are further divided into two classes: ENGR 131 – in which students solved the Travel Mode Choice MEA, and ENGR 132 – in which students solved the NanoRoughness MEA. As each MEA was implemented by faculty members, they are assisted by the TAs. TAs provided assessment of students’ work and gave written feedback.

D. Teaching Assistants’ Professional Development (PD)

One challenge in implementing MEAs, which by nature are open-ended, is providing TAs with a high quality professional development. TAs must be trained to provide feedback and grade consistently.

During the week prior to MEA implementation in actual classrooms, the TAs participated in a training session provided by a PR and a graduate research assistant (GRA) involved in MEA research. For the TAs to properly grade MEAs and provide high quality feedback, the TAs went through the following training process for each MEA (in sequential order):
1. Each TA read the MEA, answered the individual questions, and provided a solution.
2. TAs were given the rubric for the MEA and then assessed their solution.
3. TAs attended training which lasted about 2.5 hours in which they practiced assessing student work.
4. Individually, TAs graded 3 pieces of sample student work on the MEA and provided written feedback and assessment for each sample via an online system. TAs reviewed their assessment of student work side-by-side with that of an expert.

E. Post-doctoral researcher (PR) Experience

The PR involved in MEA TA-professional development (TA-PD) has a doctoral degree in Biomedical Engineering. During her doctoral training, aside from her thesis research, the PR was involved in teaching MEAs while a TA for the required first-year engineering problem solving and computer tools course. She later served as a GRA studying students’ problem formulations within MEAs. During her post-doctorate training, she has continued to study students’ problem formulations within MEAs, with additional research into MEA feedback and assessment. Engaging in teaching and educational research pertaining to MEAs in graduate school exposed the PR to teaching theories and new teaching techniques. It also gave the PR the opportunity to practice teaching in front of an engaged audience (e.g. TAs who are partners to those involve in MEA course reformation) where the audience provided immediate feedback.

III. Tasks Performed by the PR/PR Experience

A. PR TA-PD Task Assignments

The PR was responsible for delivering general pedagogical content as well as instruction on rubric implementation and providing feedback. There are two parts of the pedagogical content: problem formulation and mathematical modeling. The PR modified available training materials, with an aim to address TA feedback and confusion over some terms in the content and assessment dimensions. Addressing deficiencies in previous MEA implementations was initiated by looking into TA feedback on students’ solution from previous semesters, past PowerPoint TA-PD lecture slides, TA handouts, students’ reading materials and students’ homework. This allowed modification to the PD content and instruction targeted to fit the needs of current students and changes in course objectives.

The list of task underwent by the PR was follows:
1. Understand content of prior MEA TA-PD PowerPoint slides. This required reading the course syllabus, the MEA problem statement, sample student work on this MEA, experts’ assessment of this sample student work, and past semester TAs’ feedback on this sample student work.
2. Modify PowerPoint slides to accommodate new content that could address TA confusion over poorly defined terms associated with MEAs and provide samples of actual TA feedback on this sample student work.
3. Understand MEA assessment dimensions. There are two overarching MEA assessment dimensions: the mathematical model and generalizability. Generalizability consists of aspects of communication of the model: the product the student teams produce must be share-able (i.e. the direct user can apply the procedure and replicate results), re-usable (i.e. the procedure can be used by the direct user in new but similar situations), and modifiable (i.e. the procedure can be modified easily by the direct user to use in different situations).
4. Address TA feedback. Feedback should be provided to the TAs during PD, in addition to the experts’ online feedback that addressed issues pertaining to their grading performance on actual students’ solution. Samples of past TA feedback on students’ solutions was added to the PD slides to provide discussion points on what not to write for feedback while providing examples from expert feedback.

5. Analysis of TAs solutions. During post-training, the PR provided an analysis of TA training assessments in comparison to experts’. In the analysis, each TA is ranked with where they stood in applying the MEA Rubric in comparison to their peers.

B. Preparation Experience

The PR used the following model to prepare TA training: plan, rehearse and refine. The training preparation tries to emulate the actual experience of faculty when preparing for actual classrooms instructions. The PR coordinated meeting with course coordinators, prepared instruction schedule, met with GTAs, rehearsed oral delivery, prepared to address feedback, and become familiar with course content, while at the same time remaining attentive to students’ need.

The preparation for an MEA training session consists of the following activities in sequential order:

1. The PR met with the ENGR 131 and ENGR 132 course coordinators. In the meeting, the PR was presented with a schedule for TA training and associated MEA topics. The course coordinator was a good resource for the PR to receive clarification on the course syllabus and student/TA deliverables due dates. Since the course coordinator served as a communicator between faculty and TAs, the PR provided them with information on TA preparation materials and deliverables a week prior to training day. Also, the PR emailed handouts materials to a course coordinator to be printed a day before a training session. The PR learned the importance of being on top of existing schedules and that effective communication with the course coordinators could clarify confusion and could avoid future implementation problems.

2. The PR received information on TAs groups participating in the training sessions. There were two training sessions: a full training session (2.5 hrs) targeted for inexperienced TAs, and a focused training session (1.5 hrs) targeted for experienced TAs. The focused training session differed from the full training session in that it omitted the general introduction to MEAs and information on team roles. It provided only a brief discussion on MEA problem formulation but placed more emphasis on ways to improve feedback and providing consistent grading, and clarified specific TA confusion. The information omitted from the full training session was still available to TAs, but was not presented or discussed during training. The focused training session ended with a casual discussion on ways improvements could be made to the TA training. This experience taught the PR how to deal with different students’ background knowledge and experiences with the subject being taught.

3. The PR worked at comprehending and understanding the training materials. Materials for the full training session are well established. They consisted of PowerPoint slides, the assessment guide (I-MAP), and sample students’ solutions with expert reviews. The content of the PowerPoint slides included an introduction to MEA problem solving, team roles and activities, MEA definitions, MEA problem formulation, MEA memo format and elements of
a working model, and two sample students’ solutions. The PR practiced assessing student work on the MEA with the available student work samples, compared her assessment with that of experts, and discussed content and confusion with the GRA involved with the training and a faculty MEA reformist. This included discussions around problem formulation in engineering practice.

Further, the PR had to understand elements that constitute a high quality MEA solution and particularly a high quality mathematical model. In general, high quality MEA solutions are a written procedure in a memo format. The memo format should consist of an introduction to the procedure and what it intends to do, the procedure steps for successful execution of the model by the direct user, and results obtained by applying the procedure steps to specific data provided in the problem. A high quality mathematical model is dependent on the engineering context. For the Travel Mode Choice MEA, a high quality mathematical model is quantitative and logical, so that the model is able to 1) predict a students’ travel mode choice and 2) assess the quality of the model developed. The model should have clear articulation of the variables involved in the model, treat data types mathematically equivalently, combine data types only having similar units, have a means of eliminating the drive choice when no car is owned, have a means of incorporating proximity to bus stop and bus frequency, and have a clear description of terms like “best” and “worst”. For the NanoRoughness MEA, a high quality mathematical model has a clear definition of roughness, a sampling method that meets the direct user’s needs for quick and easy method for computing roughness, uses sufficient data for statistical analysis, uses one or more statistical measures, and accounts for variation in AFM image sizes. This experience taught the PR that being prepared requires preparation and practice with course content, and working with experts on the subject can help accelerate content understanding. Using experts’ example as reference is a quick way to learn and adapt approaches taken by experts in problem formulation, problem solving and mathematical modeling of realistic open-ended engineering problems.

4. The PR modified the PowerPoint slides to address TA confusion over poorly defined terms, TA difficulty with using rubric dimensions, and general instruction content. In particular, the PR added definitions to clarify the MEA assessment dimensions sub-terms. These sub-term definitions were not included in the original training materials. The MEA assessment dimensions sub-term definitions are listed in Table 1. To address TA struggles with implementing the rubric, the PR provided examples of how to use the rubric to past semester students’ solution. These examples was shown concurrently with experts’ assessments.

5. The PR modified the MEA PowerPoint slides to address prior semester issues with TA feedback by using actual samples of TA feedback from the previous semester. Deficiencies in past TAs’ feedback were identified to be the following:
   a) Not understanding the definitions of generalizability – re-usability, modifiability, and share-ability.
   b) Putting feedback in the wrong place in the MEA Rubric (e.g. feedback in the mathematical model complexity comment area of the MEA Rubric was actually addressing re-usability).
   c) Judging the students’ solution too quickly without testing their procedure on the actual dataset.
d) Feedback is too general without specifically stating problem areas (e.g. “you have addressed all comments from the previous draft”).
e) Contradicting and confusing feedback (e.g. “good job but you did not provide re-usability in your mathematical model”).

6. The PR practiced grading and give feedback on student solutions based on a standard rubric. This is done by referring to the Instructors’ MEA Assessment/Evaluation Package (I-MAP). The I-MAP serves as a guide to apply the MEA Rubric for a specific MEA. The MEA Feedback and Assessment Rubric (MEA Rubric) is discussed in greater detail in\textsuperscript{11}. By practicing using the rubric prior to teaching the TAs about it, the PR was prepared to give tips and clarify the rubric implementation, and can even provide suggestion for TAs on how to use the rubric and IMAP effectively. In actual classroom implementation, students might have questions on their grades and the grading process. This preparation by the PR helped avoid difficulty during the TA-PD. The PR was able to continuously provide feedback and answer questions during the TA-PD while the TAs tried to apply the MEA Rubric to sample student work.

In summary, the above experiences provide training to the PR in the following ways:

- Effective communication with the course coordinator.
- Planning of instructions prior to implementation.
- Refining instructions content based on students’ (in this case TAs’) needs.
- Applying teaching strategy based on content to be delivered.
- Learning how to provide constructive and useful feedback.
- Learning how to address rubric assessment issues associated with open-ended problem solving.
- Learning new ways to help students (here TAs) improve understanding of materials in comparison to experts.
- Utilizing experts’ solutions to effectively teach and provide feedback on solutions to realistic open-ended problems.

Table 1. MEA Assessment Dimensions and Sub-term Definitions

<table>
<thead>
<tr>
<th>MEA Assessment Dimensions</th>
<th>Definitions</th>
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<tbody>
<tr>
<td><strong>Re-usability</strong></td>
<td>The procedure can be used by the direct user in new but similar situations</td>
</tr>
<tr>
<td><strong>Re-usability sub-terms</strong></td>
<td></td>
</tr>
<tr>
<td>Criteria for success</td>
<td>Elements of a good solution</td>
</tr>
<tr>
<td>Constraints</td>
<td>Limitations imposed by the data</td>
</tr>
<tr>
<td>Assumptions and limitations</td>
<td>A clear statement about the situation to which the procedure applies</td>
</tr>
<tr>
<td><strong>Modifiability</strong></td>
<td>The procedure can be modified easily by the direct user for use in different situations</td>
</tr>
<tr>
<td><strong>Modifiability sub-terms</strong></td>
<td></td>
</tr>
<tr>
<td>Rationales</td>
<td>justifications of procedural steps based on more than personal experience</td>
</tr>
<tr>
<td>Assumptions</td>
<td>clear statements associated with individual procedural steps</td>
</tr>
</tbody>
</table>
C. Delivery Experience

The delivery experience consisted of both oral presentation and discussion. The PR first provided a PowerPoint lecture divided into two major topics: problem formulation and mathematical modeling. Discussion topics included grading, the Spring 2010 TAs’ feedback on student work, and how to properly give feedback.

The delivery of TA-PD training is challenging due to several factors. The first factor is the potential for of multiple solutions to the MEAs which results in multiple unbounded questions from the TAs and the need to effectively address these questions during training. The second factor is conveying the teaching pedagogy that has to go hand-in-hand with TA feedback. The PR meth these challenges in the following way:

- The PR used work of experts and samples of high quality solutions as guides in teaching the TAs about feedback. TAs were provided with high quality solutions and actual students’ solution. Discussions were based on these materials.
- The PR employed a teaching strategy in TA training that was deliberately two-way. Teaching assistants – who are considered students in this case, engaged in discussion with the PR and the GRA. Teaching assistants should function as “partners in innovation”; their input is vital to their professional development and improving MEA instructions\textsuperscript{12}.
- The PR was attentive to the audience in the training sessions. Audience information is also important for effective delivery. The graduate students were found to be more engaged than the undergraduate students, mainly because the graduate students were more comfortable dealing with the PR, as they might have viewed her as a colleague rather than a faculty member. The undergraduate students were at first more passive; they did not ask questions. Seeing the differences in attitude, the PR stimulated discussion by asking the TAs more questions. This provided the PR with immediate assessment of the TAs understanding.

TA understanding of MEAs and the quality of their feedback to students were the main targets of improvement to the MEA instruction. Several efforts have been conducted by the MEA research group to analyze students’ responses to MEAs and TAs’ feedback on student work. This has included a comparison of TA and expert scoring\textsuperscript{11}, progression of students’ mathematical models\textsuperscript{13}, and s progression of students’ problem formulations\textsuperscript{14,15}. The results of the research has helped reform the content of TA training materials, MEA design, and the MEA Rubric and I-MAPs. This dynamic nature of MEAs also has helped the PR to acquire adaptive expertise – an ability to adapt instruction to ever-changing student needs\textsuperscript{16}. This also provided the experience with utilizing research to enhanced and informed classroom instructions. Since research is often current and changing, classroom instructions should also acquire these traits.

In summary, the experience of preparing for and conducting TA-PD training presented the PR with challenges associated with teaching open-ended modeling problems and training TAs to
provide consistent grading and effective feedback. To be able to teach with realistic problems such as MEAs and to train TAs effectively depends on both mastering the content knowledge of the subject to be taught, and also developing knowledge of the audience. Knowing the audience and their level of knowledge on the subject to be taught helps stimulate effective in-class discussion. This is congruent with the ideas on the importance of being teachers that are thoughtfully adaptive17.

IV. Ways to Use Course Innovation for Enhancing the Post-Doctoral Experience

A. Take Advantage of Faculty Mentor(s) Knowledge of Innovation.

A PR should seek faculty mentor(s) to specifically support teaching efforts and innovation. It is an advantage for PRs to be involved in reformation efforts which includes TA-PD. The PR learned to teach and improve training materials. At the same time, the PR received simultaneous feedback from a faculty reformist. Seeking help from a faculty reformist helped the PR to develop a vision for an effective training session. For example, the faculty mentor reviewed instruction provided by the PR and allowed new content formed by the PR to be presented to the TAs. Having a role model is always desirable for new faculty members18; their work ethics and profound experiences can direct new faculty in their professional careers.

B. Establish Peer Collaboration Around the Innovations.

A PR should engage in peer collaboration to gain insights into the innovation, in this case TA-PD training. The PR conducted the training session with the help of a GRA involved in MEA research. The GRA’s research focused on MEA mathematical modeling13. His expertise offered a more concrete and coherent understanding of the mathematical models students create in response to MEAs. The PR discussed the training materials with the GRA, and incorporated his advice pertaining to teaching mathematical modeling. To be able to communicate and collaborate with peers and faculty is an essential skill. Collaboration with the GRA helped to add perspective on TA-PD training and research around TAs. The PR learned new content knowledge and effective ways to train TAs. In addition, peer collaboration helped reduce confusion over the MEA content and provided new insights into improving TA-PD and teaching as a whole.

C. Using innovation as means to gain practice public speaking in classroom format.

A PR who is an international student and a non-native English speaker should use teaching as sites to improve public speaking. TA-PD provided this for this PR. Improving public speaking comes with practice, and seldom do PRs have the chance to improve their public speaking aside from participating in oral conference presentations. Teaching a lesson in a classroom is quite different than a conference presentation, as teaching is flexible and two-way.

D. Challenges unique to open-ended problem solving.

A PR should utilize TA-PD training to learn new ways to teach engineering. Since the introduction of MEAs in 2002, MEA faculty reformers have experienced resistance from both
TA and students towards the MEA implementation, primarily because the nature of MEAs is a departure from traditional engineering problem solving exercises\textsuperscript{19}. In traditional engineering classrooms, one often solves textbook problems and receives solutions –for which there is often only one solution\textsuperscript{20}. This differs from real-world engineering problem solving, which is better emulated by MEAs. TA-PD training provided the PR sites to experience the challenges with implementing real world engineering problem solving in classroom settings. It required continuous innovation on the instructor’s end, to stay at the forefront of the engineering content knowledge, and to be able to translate the knowledge in teaching.

Other challenges are associated with evaluating success of students’ MEA solutions. Success in traditional engineering classroom problem solving is often evaluated based on standard engineering criteria – to calculate correct numbers and to produce working projects\textsuperscript{20}. Traditional engineering problems do not reflect real-world engineering practice. MEA problem solving looks more into satisfying user needs, where students produce solutions which are mathematical models, within a given time constraint (i.e. deadline) for a user. Hence, evaluating solutions resulting from MEA problems comes with its own challenges where there is not one right answer. Even more challenging; implementing instruction with such problems is not common practice in engineering classrooms – one rarely finds a working classroom model to emulate.

The PR found ways to work around these challenges by learning how MEA assessments are made. In particular, to assess MEA problems, high quality MEA solutions were used as a standard guideline. A rubric was designed to address the open-ended nature of the solutions. Evaluation criteria of a written procedure are based on two major components – the mathematical model and generalizability. These two components are evaluated independently. A detailed overview of the MEA rubric assignments is discussed in Verleger et al.\textsuperscript{11}. A PR learning about assessment for MEA problem solving can adapt lessons similar in nature to one’s own classroom practice.

E. Advice on Teaching that Helps PR Positive Experience.

Teaching is not an easy profession, as evidenced by successful educators\textsuperscript{21,22}. However, resilience amongst novice teachers and new faculty is an important psychological factor for becoming a successful teacher and successful mentor. Tait (2008) defines resilience as “a mode of interacting with events in the environment that is activated and nurtured in times of stress”. It was also found that new faculty and teachers who had high self-resilience have greater satisfaction with teaching\textsuperscript{23}. In order to nurture resilience in her role, the PR sought resources that contributed to building self-resilience. This was initiated by establishing productive relationships with those who value teaching and understand the challenges that come with teaching. Seeing difficulties as challenges can provide motivation for making things work and being productive. In addition, the PR had experienced being a teaching assistant during her graduate studies. These prior experiences helped build self-resilience.
H. Advice on Managing Time.

Another important aspect to successfully conduct TA-PD is effective time management. Time management is an essential skill to succeed in any profession. The ability to balance between achievement in teaching and research is an essential skill in becoming a successful faculty member. The PR balanced her time between training the TAs and conducting her own research, as typically experienced by faculty members, though the portion of activities is less than a faculty role. One of the activities that helped in managing time effectively was to plan the training activities well. Identifying deficiencies early in the instruction and training materials helps provide a smoother training session.

Conclusions

The experiences outlined here involve aspects of course innovation, and the planning, preparation, and course delivery that comes with it. Model-Eliciting-Activities, as an example of a course innovation, provide sites for postdoctoral researcher training in teaching and curriculum and instruction development. The PR not only engaged in the teaching of TAs, she also added to the innovation by creating some new TA training materials.

As actual students’ solutions were used in the instruction, it is imperative to have the necessary preparation to understand students’ solutions, and to provide expert feedback on the solutions. Since multiple solutions exist to open-ended problems, it thus comes with unpredictable questions from the TAs. This is an invaluable experience for the PR, since mastery of content is not enough – one must also know how to impart knowledge to others by answering unexpected questions. In real classrooms, students will come with questions and only with preparation and training can an instructor deal with such situations.

To help with TA training preparation, available training materials were used to the PR’s advantage. The materials functioned as references that can guide training. In real classrooms, a new faculty member is expected to provide their own teaching materials, which is a greater challenge. Teaching MEAs to the TAs with the help of available training materials has helped the PR learn how to prepare materials for instruction and handle the difficulties that come with classroom preparation.

Peer collaboration is a must in enhancing teaching because one’s knowledge complements another’s. In this example, the PR’s expertise was in MEA problem formulation, while the GRA’s expertise was in MEA mathematical modeling. Only through collaboration could the instruction for TAs on the specific topics be well planned and cohesive. The experiences faced by the PR were similar to those encountered by new faculty members, where seeking help from colleagues with similar backgrounds or with complementary expertise could help enhance the teaching of a subject.

Furthermore, having faculty mentors that have similar goals in engineering education helps accelerate learning and provides support for innovation efforts made in engineering curriculum and instruction. Successful educators are those who always seek resources that help their
teaching. By asking for help from peers and experienced faculty mentors, one not only builds strength in teaching, but also creates a productive teaching community.

The PR’s experiences with conducting TA-PD with MEAs provide insights into the challenges associated with implementing authentic engineering problems in classrooms. These experiences also offer insights into using course innovations as sites for PR training in curriculum instruction and development. Implementing course innovations on engineering subjects requires careful planning and time management, while examples from previous implementations are useful resources. Examples could be obtained from available lecture materials, course syllabi, rubrics, education research articles that were published pertaining to the innovation, and from direct interaction with faculty reformers. Furthermore, training of TAs is a must so they can provide help with instruction, grading and feedback. This requires the TAs to be also actively involved in the innovation aspects of the course. It is also imperative to work on giving useful feedback to solutions of open-ended problem, which this requires, heavy analysis of students’ solution. In helping with the analysis, a comprehensive rubric is required. Overall, course innovation is a collective effort from those who are directly or indirectly involve. The training with course instructions and development presented here could be adapted to other engineering classes at undergraduate or graduate levels that aim at exercising real world problem solving. Overall, this could provide a stepping stone to improve engineering education as a whole.

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