AC 2011-1918: STUDENT RESPONSES TO AND PERCEPTIONS OF FEEDBACK RECEIVED ON A SERIES OF MODEL-ELICITING ACTIVITIES: A CASE STUDY

Amanda S. Fry, Purdue University

Amanda Fry is a doctoral candidate in Art Education at Purdue University. She received her B.S. in Art Education from Indiana State University and her M.A. in Art Education from Purdue University. Her research interests include qualitative research in engineering education and investigating the effects of an instructional model in which academically struggling secondary students mentor elementary students in the creation of artwork as a means of improving their academic performance.

Dr. Monica E Cardella, Purdue University, West Lafayette

Monica E. Cardella is an Assistant Professor of Engineering Education and is the Co-Director of Assessment Research for the Institute for P-12 Engineering Research and Learning (INSPIRE) at Purdue University. Dr. Cardella earned a B.Sc. in Mathematics from the University of Puget Sound and an M.S. and Ph.D. in Industrial Engineering at the University of Washington. At the University of Washington she worked with the Center for Engineering Learning and Teaching (CELT) and the LIFE Center (Learning in Informal and Formal Environments). She was a CASEE Postdoctoral Engineering Education Researcher at the Center for Design Research at Stanford before beginning her appointment at Purdue. Her research interests include: learning in informal and out-of-school time settings, pre-college engineering education, design thinking, mathematical thinking, and assessment research.

Heidi A. Diefes-Dux, Purdue University, West Lafayette

Heidi Diefes-Dux is an Associate Professor in the School of Engineering Education at Purdue University. She received her B.S. and M.S. in Food Science from Cornell University and her Ph.D. in Food Process Engineering from the Department of Agricultural and Biological Engineering at Purdue University. Since 1999, she has been a faculty member in Purdue’s First-Year Engineering Program, the gateway for all first-year students entering the College of Engineering. She is currently the Director of Teacher Professional Development for the Institute for P-12 Engineering Research and Learning (INSPIRE). Her research interests center on implementation and assessment of mathematical modeling problems.

©American Society for Engineering Education, 2011
Student Responses to and Perceptions of Feedback Received on a Series of Model-Eliciting Activities: A Case Study

Abstract

One challenge in implementing open-ended problems is assessing students’ responses because the open-ended nature of the problems allow for numerous suitable, “good” responses. Specifically, formative assessment - providing the students with feedback on intermittent solutions - can be especially challenging when it is hoped that students will understand and respond to the feedback in ways that indicate learning has taken place. The aim of this study is to examine how students in a first-year engineering course perceive and respond to feedback received from a Graduate Teaching Assistant (GTA) and their peers as they iterate through multiple drafts of their solutions to Model-Eliciting Activities (MEAs). In this paper, we report case findings based upon three interviews each from four students from a single team that participated in the interviews following three MEAs implemented in a single semester. Findings indicated all four students struggled with the feedback received from their peers. The students agreed GTA feedback was helpful in improving their MEA solutions and was more useful than the peer feedback. However, the students had contradictory perceptions of the level of specificity and vagueness in the GTA feedback. This study supports the notion that students need training and education both in how to give feedback as well as how to respond to feedback.

I. Introduction

Internationally, engineering educators have recognized the necessity of students acquiring teaming and communication skills, aptitude in engineering science and design, ability to apply mathematics, and an ability to address open-ended, ambiguous problems. To achieve these competencies, one instructional approach that has been developed is Model-Eliciting Activities (MEAs). MEAs are realistic, open-ended, client-driven problems that require the construction or variant of a mathematical model for a particular set of circumstances. In engineering education, one essential element of all MEAs is the emphasis on the process of solving the problem. Stress is placed less on an answer to an instance of the problem than on a process for solving the problem. For instance, in the Paper Plane Challenge, the major product is a procedure to “select a winner for four awards (i.e. most accurate, best floater, best boomerang, and best overall) given three competition levels: beginner, intermediate, and advanced and measurements taken during the competition. Student solutions to MEAs are therefore shareable, modifiable, and reusable tools for solving the immediate problem as well as similar problems that could be encountered in the future.

MEAs and Feedback

MEAs focus on higher-order thinking and problem solving. Because there is not one correct answer to any given MEA, formative feedback plays an important role in the revision of MEA solutions. According to Stobart and Gipps, feedback can only be considered to be formative if it, “feeds back into the teaching-learning process” (p. 18). They argue that the feedback given
should enable the student to close the gap between the actual and desired performance. Verleger and Diefes-Dux found that students are capable of creating high quality MEA solutions if given the opportunity to revise the solution following formative feedback\textsuperscript{6}. Typically, students receive feedback at multiple points during the MEA implementation as they create multiple draft solutions. Students compose their initial draft, receive feedback from an instructor or graduate teaching assistant, create a second draft, receive feedback from peers, then compose their final draft. The first draft MEA solutions typically do not address the complexity of the problem—they are poor quality models. Following instructor feedback, the second drafts were created. Second drafts were reasonably acceptable, but lacked the finer attributes of a high quality solution. Final responses, created after peer feedback, were usually not greatly different than draft two but made the critical changes necessary to create a high quality solution\textsuperscript{6}. This aligns with the research of Black and William\textsuperscript{7}, whose research suggests formative feedback improves learning when it gives students specific guidance on strengths and weaknesses.

Although feedback is critical in helping students succeed\textsuperscript{6,8}, the quality of the feedback is a key trait in any procedure involving formative feedback\textsuperscript{7}. Razmov and Vlassesva noted the following qualities of successful instructor feedback: easy to access, robust, impartial, explicit, encouraging, timely, and iterative\textsuperscript{9}. To provide successful feedback, Smith and Gorand suggested providing students with guidance on how to improve as well as an understanding of how to make an improvement\textsuperscript{10}.

Because quality feedback is important, investigating the traits of good feedback is critical. The aim of this study is to examine how students perceive and respond to feedback received from a Graduate Teaching Assistant (GTA) and their peers. This study is part of a larger project that focuses on the feedback that students receive as they iterate through multiple drafts of their solutions to MEAs. In addition, this study is part of a greater research endeavor to develop pedagogical approaches around feedback on open-ended problem solving that enhances instructor and peer feedback and facilitates students learning to interpret and respond to feedback.

II. Method

A. Setting

Three MEAs, \textit{Paper Plane Challenge}, \textit{Just-In-Time Manufacturing}, and \textit{Travel Mode Choice}, were implemented in Fall 2008. For MEA 1: \textit{Paper Plane Challenge} student teams used data to construct a procedure (model) for judging paper airplane contests, for MEA 2: \textit{Just-in-Time Manufacturing} student teams provided a model for ranking shipping companies, and for MEA 3: \textit{Travel Mode Choice} student teams developed a model from data to make predictions about students’ transportation choices in order to inform a university’s master development planning process. A more detailed description of these MEAs is provided by Zawojewski, Diefes-Dux, and Bowman\textsuperscript{3}. The MEAs were part of a required problem-solving and computer tools course in the first-year engineering program. Approximately 1200 students were enrolled. Figure 1 shows how an MEA was implemented in Fall 2008\textsuperscript{11}. 
Figure 1. Fall 2008 MEA Implementation Sequence.
Before students worked on any MEA, they were introduced to the nature of these activities by solving and debriefing a relatively straight-forward one with faculty in the lecture setting. Prior to attending this lecture, students were asked to read the problem context of an MEA and individually develop a method to solve it. During the lecture, mathematical models and model development processes were discussed. Students worked in teams to develop a solution based upon their individual homework solutions. Several student solutions were presented to the class to highlight their differences. Following the presentation of solutions, the lecture shifted away from simply solving the problem to developing a high quality, generalizable, and sharable procedure that meets the current and future needs of the client. The MEA Rubric was also discussed. The lecture concluded with an explanation of the role of the GTA as a facilitator and a summary of the MEA sequence that would take place over the following weeks.

Prior to the first MEA, students were placed in teams of four. GTAs facilitated the laboratory implementation of the MEA in which each team developed a first draft of their MEA solution. After class, each GTA provided feedback and assessment to fourteen to fifteen student teams. Each team used the GTA feedback to revise their initial solution. Following revision, student solutions were submitted to peers in a double-blind review. Using the peer feedback from 1 to 4 peer reviewers, each team created a final response that was submitted to the GTA for feedback and assessment. GTA feedback on the final response was intended to help the team perform better on subsequent MEAs. The entire MEA process was sustained by a web-based interface connected to a database system. The system managed all iterations of student solutions, GTA feedback and assessments, and the peer review process.

GTAs received recurrent professional development with MEAs to make certain they were able to adequately provide feedback to help students achieve a high quality solution. Prior to the start of the semester, GTAs participated in an 8-hour training session over two days to introduce them to MEAs. Verleger reported the training included a discussion of the challenges of assessment and feedback on solutions to open-ended problems. The MEA Rubric was introduced to the GTAs. Using the MEA Rubric, each GTA evaluated two pieces of student work. The GTAs then participated in a discussion comparing and contrasting their scores to an expert’s scores. As a follow-up assignment to the training session, the GTAs practiced evaluating 3-5 pieces of prototypical student work. The GTAs received individual expert feedback on their reviews. For the remaining 2 MEAs, GTAs attended a meeting prior to the implementation in which they developed solutions to the new MEA, discussed prototypical student solutions, and appropriate feedback and assessment. After each meeting, GTAs practiced evaluating additional prototypical student work as described above.

The students creating the MEA solutions also received training on providing and interpreting feedback. Students participated in a lecture on how to interpret feedback before they received GTA feedback on their MEA. Prior to engaging in the double-blind peer review process, students were given a sample MEA solution to evaluate. After their evaluation was submitted, students were shown their review next to an expert’s review of the identical solution. Students self-reflected on how they could improve their feedback. Students completed peer reviews of their MEA solutions the following week.
B. Data Collection

As previously stated, this paper reports on one piece of a larger study aimed at investigating the role of feedback in students’ model-development process. The larger study included collection of copies of student work, copies of peer feedback generated by students, copies of GTA feedback; video-recordings of teams of students making revisions to their solutions, and interviews with students as well as GTAs. This paper focuses on interviews with students.

Interviews were conducted at three points during the semester. The first set of interviews occurred near the beginning of the semester after the GTAs provided final feedback on the Paper Plane Challenge MEA. A total of 41 students participated in this interview. Approximately half way through the semester, a second set of interviews with 24 students occurred following GTA final feedback on the Just-in-Time Manufacturing MEA. Near the end of the semester, the final interviews were conducted following GTA feedback on the Travel Mode Choice MEA. The interviews were conducted with the students individually, were audio recorded, and lasted approximately 20 to 30 minutes. This paper focuses on a single team of 4 students. Other papers will examine the complete data set.

This study made use of semi-structured interviews. The majority of the interview questions were predetermined, but the order and wording of the questions was flexible. If appropriate, interviewers were free to ask additional follow-up questions. For the complete interview protocol, see Appendix A. Some of the questions on the interview protocol were: Can you please describe for me the type of feedback that you received from your TA? How did your team respond to this feedback? Did you encounter any challenges in responding to the feedback from your TA? If yes, how did you work around these challenges?

C. Data Analysis

All interviews were transcribed verbatim. Transcribed interviews were coded using an emergent coding scheme in which categories were created based on a preliminary examination of the data. All coding took place using NVivo software. After the data was coded, the interviews were examined for commonalities and differences in the codes present in themes such as the helpfulness of peer feedback and importance of GTA feedback in each student interview. Similarities and variations in the themes that emerged from the student interviews are the focus of the findings. To better understand the perceptions and responses to feedback received from a GTA and from peers, this paper will examine the work of one team of students. Taking a case study approach and focusing on just one team allows us to take an in-depth look at the experiences of the one team across the three different MEAs. A key feature of this approach is the fact that we are able to understand the team’s experience through multiple lenses: the individual student interviews which show four different perspectives on the same experience and the actual feedback from the GTA. The particular team chosen for case study analysis in this paper was selected because it had a complete data set. It was the only team in which all of the students participated in all of the interviews.
III. Findings

The team of 4 students whose interviews are the focus of this paper created their MEA solutions together. They received the same feedback from their GTA and their peers. Naturally, there were a number of similarities in their interpretation of the feedback received. However, there were also notable differences in their perceptions of the feedback from their GTA and peers. In this section, examples of their perceptions are given, including quotes from each interview, as well as the actual feedback received under the following categories: “GTA Feedback on MEA 1”, “GTA Feedback on MEA 2”, “GTA Feedback on MEA 3”, “Peer Feedback on MEA 1”, and “Peer Feedback on MEA 2” and “Peer Feedback on MEA 3”. Pseudonyms are used for the student names. For an example of the rubrics used for assessment, see the Travel Mode Choice rubric in Appendix B.

GTA Feedback on MEA 1

The GTA provided the following written feedback on the math model portion of MEA 1:

“In a high quality model:

- For each competition category, there must be a clear definition of what constitutes success and a complete procedure leading to a single winner. Competition categories: Most Accurate, Best Floater, Best Boomerang and Best Overall.
- Method(s) for breaking ties should be described.
- Methods for dealing with missing data should be described.
- For the Best Floater, there is consideration for the Length of Throw and Distance from Target.
- For the Boomerang Throw, there is an accounting for whether the turn was made or missed. The definitions for Length or Throw and Distance from Target can be used to determine whether the turn is made or missed.
- If statistical measures are used, like averages in your case, they are applied correctly. For instance, accuracy cannot be measured solely using an average of Distance from Target as average does not account for precision. Consider that three throws of 4, 5, 6 meters with an average of 5 meters from target for a straight throw is not the same as three throws of 4.8, 5, and 5.2 meters with an average of 5 meters. A team with three throws of 4.9, 5.1, 5.2 meters with an average of 5.1 meters actually is demonstrating more precision though the average is slightly higher.
- Critical steps that need justification / rationale:
  Dropping out type of throw (e.g. it was not clear if you used the Straight Path or Boomerang Path data in your calculations)
  Dropping out type of data (e.g. length of throw was not used at all in your procedure. Is there a justification / rationale?)
  Methods for breaking ties
  Methods for handling missing data
  Steps that involve combining data types (you may want to consider using two or more different types of data to find a winner and give reasons for your method)”

Following the first draft of each MEA solution, the team received feedback from their GTA. Because there is no one correct solution to an MEA, GTAs are encouraged to guide the students with formative feedback based upon their current solution. The students on this team agreed that
the GTA’s feedback on their math model were the most beneficial to their subsequent revisions. Dave commented on what helped their team:

“I think… giving us hints on what we need to have in the mathematical model, telling us that it needs to be kind of simple and just telling us some stuff that we should think about.”

The team also thought the feedback on MEA 1 helped them to better understand what was expected of them. Because the students are new to MEAs, this was beneficial. Jerry discussed what was helpful about TA feedback.

“Just learning what it is they’re looking for when they’re grading it because obviously, the first time you do it you have absolutely no clue what they want and then just getting the TA feedback the first time just gave you really specific, like this is what we want, we want it in this order, so it makes it easier for the next time.”

The students also believed the GTA feedback they received was more important than the feedback received from their peers. This notion was primarily tied to the GTA’s role as grader, as exhibited by the comments of student Dave:

“They know what they’re grading on so if they’re telling us what they're grading on then we can change it so we get a good grade hopefully.”

Ryan agreed:

“We went with the TA’s suggestions because they were obviously grading it and it’s not our own . . . opinions.”

The team members had completely different perceptions of the level of specificity and vagueness in the feedback they received from their GTA. After the first MEA, some of the students did not believe the GTA even read their math model. This perception was probably due to the GTA’s use of general feedback that would apply to any solution. Dave described the feedback on the math model:

“I thought a lot of it seemed to be really vague that could probably be applied to everyone's kinda -- some people on my team actually thought maybe they didn't even read them, they just plugged stuff in. The stuff on the mathematical model I think especially… just didn't really seem to apply to ours at all.”

Ryan believed the feedback on the math model was detailed. This was in conflict with the rest of the team members, who all perceived the feedback as vague. Ryan described the math feedback received from their GTA:

“We got really lengthy… more detailed feedback from the TA that went over kind of every aspect of our model… it gave us kind of like a rubric for modeling our next draft.”

Sam clearly disagreed with the previous interpretation. Sam described the GTA feedback as:

“very general and some seemed like it could be applied to our project, some… seemed like he just copy and pasted it into everyone's”.

The team made changes to their solution based upon the GTA’s feedback. Ryan described their response:
“He provided lots of feedback and we wanted to make sure we could cover every aspect so we got a good grade.”

Sam reported a similar degree of change:

“We fixed what we thought that we needed to fix and what we already saw in there we elaborated on.”

The students also agreed specific feedback from the GTA was most helpful. Two team members stated they desired more feedback from the GTA that was directed to their particular model. Dave expressed this desire for more specific feedback as well as Sam who stated GTA feedback should be improved:

“Instead of writing totally general comments… I think… (TAs should) write specific comments.”

GTA Feedback on MEA 2

On MEA 2, the GTA provided the following feedback on the math model:

“In general, you are showing a good understanding of the problem. To enhance your procedure, however, you must show your ideas in an organized fashion. In addition to that, here are some ideas to improve your procedure: A clear statement describing the basis for the ranking system needs to be provided before the procedural steps. It is unclear why you are using the SST? What does the SST measure? You may use a number of statistical measures simultaneously, or one following the other. You may also use one measure to produce an answer and another to “check” how well the answer works, leading to a possible revision. Results from statistical procedures may be aggregated in some fashion using rankings, formulas, or other methods.

In a high quality model:
- The procedure looks past measures of central tendency and variation to look at the actual distribution of the data, where attention is drawn to the frequency of values, particularly minimum and maximum values.
- Final overall ranking measure or method must be clearly defined. Completes the sentence, the ranking procedure is based on…
- Critical steps that needs justification / rationale:
  When teams use any statistical measures, these measures must be justified – explain what these measures tells the user.
  -When developing intermediate ranking or weighting methods, these must be justified. At a minimum, the mathematical model should include assumptions about the situation and the types of data to which the procedure can be applied. This would be accomplished by more thoroughly completing the following memo outline requirements:
  I. Introduction
    A. In your own words, restate the task that was assigned to your team (~1-2 sentences). This is your team’s consensus on who the client is and what solution the client needs.
    B. Describe what the procedure below is designed to do or find – be specific (~1-2 sentences)
The team disagreed on the differences between the feedback on MEA 1 and 2. Ryan and Sam believed the GTA feedback addressed smaller issues because their initial solution was better. Ryan stated:

“The feedback followed the same format of that from MEA1, and overall, the feedback was we did a lot better on our first draft than we did the last time through, which is natural.”

Ryan believed there was less feedback on MEA 2 though it was more specific than what the team received on MEA 1.

“We got a little less feedback and it was kinda more specific, just on smaller aspects of our model... It was touching up on like smaller pieces of our mathematical model and how it could be improved. And for reusability, it also had some specifics on how to make it more reusable.”

Sam agreed that the feedback was more specific on MEA 2. However, Dave and Jerry felt the feedback did not change much. In addition, Dave felt the feedback was less detailed.

“Some of the comments, I think, were almost exactly the same (as the feedback on MEA one). Kind of less information... less detailed. 'Cause on the first one they gave us hints on where we should be going and on this one not so much.”

The team did not view the specificity of the GTAs feedback in the same manner. Ryan and Sam believed the GTA feedback was more specific on MEA 2 than MEA 1. When asked to describe the feedback on MEA 2, Sam stated:

“It was more specific, ... I think we did better on the second so we got more in depth feedback to make it a better overall feel.”

In contrast, Dave thought the feedback was less specific.

“Some of the comments, I think, were almost exactly the same. Kind of less information. Less like, detailed. 'Cause on the first one they kinda gave us hints on where we should be going and on this one not so much.”

The students viewed their responses to the GTA feedback very differently. Ryan believed the team disagreed with the GTA feedback on MEA 2.

“We disagreed with a like a couple points that he put out there, but we realized that they were valid; that it might not seem better, but in reality, it made them better.”

Sam believed the team responded positively to the GTA’s feedback and made the necessary changes.

“Positively. We... liked what he said ’cause we were like, oh, yeah, we missed that!”

In contrast, Dave believed the team ignored the GTA feedback and made changes on their own.
“I don’t think that we really responded a whole bunch actually on this one… we added stuff along the way but it was just stuff that we just decided that we should do.”

Jerry had yet another interpretation of the team’s response to the GTA feedback on MEA 2. Jerry believed the team used the GTA’s feedback as a checklist.

“I mean, as far as the feedback goes, we just look at what he says and… go down the list… We just go down the list and just make sure we cover everything and look over it one thing at a time.”

**GTA Feedback on MEA 3**

On MEA 3, the GTA provided the following feedback on the math model:

“Your method is quantitative but with large gaps in the logical development of a model. Consider the following for further improvement. In a high quality model:

- Quantitative methods are employed to predict the travel mode choice AND to assess the accuracy of the model.
- There is a clear articulation of the variables included in the model to predict students’ preferred travel mode.
- When variables are described as having an order of importance, there is a mathematical accounting for the level of importance. (All variables are not treated equally).
- When variables are all treated equally, there is a description of the variables that indicates an intentionality of the equal treatment.
- Data types that are similar are mathematically treated in a similar fashion.
- When data types are combined, units are converted to allow for combining of data. • There is a means of eliminating the drive choice when no car is owned.
- The means of incorporating “Proximity to Bus Stop” and “Bus Frequency” data types into the model does not overly penalize the bus option (or dis(advantage) the walk or drive options).
- Ideas of “best” or “worst” are clearly defined and the associated mathematics is appropriate.
- Rationales need to focus on why the overall method is appropriate and why individual steps are necessary. For examples: Why is combining data types necessary”?

All four team members agreed the GTA feedback on MEA 3 was the most specific feedback they had received of all three MEAs. Sam stated:

“The feedback was just like the second, more specific, and pinpointing certain things.”

Jerry reported a similar interpretation:

“The past few times, it’s been getting significantly, like, more and more specific about what they wanna see, just a lot of the finer details.”

Ryan agreed:

“I’d say that the feedback was just more specific and not as critical in general because it was -- like, the other ones, he could be more specific and give kinda similar feedback to all the groups versus this one -- or just because you kinda had a step thing that you
needed for the first two versus on this one you needed a set thing but your method of getting to it could be anything, so...it was more personalized.”

The team also agreed that the GTA feedback helped them to make necessary changes to their model. The team made specific changes based upon their GTA’s comments. Ryan described their response to the GTA feedback:

“We had a good starting grade on it so the feedback was pretty positive for the most part. It just, he just had specific things we had to change.”

All four members of the team thought the GTA feedback most helped them improve their MEA solutions. Jerry described why GTA feedback was the most useful part of the MEA process:

“It’s just the most detailed, in-depth analysis of your memo that you could really ask for and it gives you pretty much everything that’s wrong, I feel. It really hits on all the really big things that you need to fix and some of the minor things, and then -- at least with the first one. And then by the time you’re at the end it’s hitting on all the little minor things you need to change. Like everything. Every little detail you need to look at that you overlooked. So that’s hands down the best part about it, is just being able to get such a huge chunk of what you’re doing wrong written right next to your memo so you can see exactly what you need to change.”

Dave agreed:

“The TA feedback (is most useful), like I said, I think, in one of the other interviews, they’re the ones that are grading it so they know what needs to be changed in order for you to get a good grade from them.”

The students in this team clearly valued the feedback of their GTA. They made necessary changes to their MEA solutions both to better the solution and to address the comments of the GTA who would be grading it at a later point.

Peer Feedback on MEA 1

After the students received the GTA’s feedback on draft one of their MEA, they held a meeting to make changes to their solution. Once the changes were submitted, the second draft was sent to peers to review. Following peer review, the team made final revisions to their MEA solution before submitting it to the GTA for grading. On MEA 1, the team received peer feedback from two peers.

The team received the following feedback from a peer on the math model on MEA 1:

“Most Accurate- explain how to calculate with missing data. Best Floater- explain how to calculate mean with missing data. You are assuming that the data will tell us how far the target is away because new data does not seem to follow same parameters as first data set. Also would you really want to have the lowest mean or the highest mean? Are you looking for longer or shorter airtime? Best Boomerang- Explain how to see if a plane made it around the turn or not. Also, your variable "u" says that it is the distance from turning point to target, but later you refer to it as the distance to target in you rational. Lastly, explain how to calculate with missing data. Best Overall- This section was good and had a tie breaker.”
The team also received this feedback on the math model from another peer:

“The equation for the mathematical model should be better thought out and be easily shown as to why you came up with that model, and why the calculations actually make sense to the client.”

The team was unanimous in their interpretation of their peer feedback on MEA 1. They all stated one review was helpful and the other was not. Ryan described their peer feedback:

“We got two feedbacks from our classmates. One of the feedbacks was extremely helpful and the second feedback seemed more like someone had 10 minutes and forgot to do it and basically it was, like, half sentence responses.”

Sam echoed these comments:

“The two feedbacks that we got, we got one that, I think, tried really hard and one that just quickly went over it. They probably spent maybe 10 minutes on the whole thing. One probably spent a couple hours, or an hour or so.”

The students differed in their perceptions of how they responded to their peer feedback. Jerry, Sam, and Ryan believed the peer feedback helped them to improve their MEA solution. Jerry described how the peer feedback helped them to make changes:

“I think that peer feedback was the main reason we decided to change our mathematical model for the third time, make it simpler again because the one really good feedback said it was just too complicated and we realized it was too complicated.”

Dave did not think they made many changes based upon the peer feedback.

“I don’t think we actually addressed much of the peer feedback at all because one of the feedbacks that we got was just, like, didn’t even mean anything. Like, all the points that they made we could point out we have this here, we this here, so that’s just, like, threw that one out. And the other one we responded to that a little bit but not as much as the TA feedback.”

**Peer Feedback on MEA 2**

The team received feedback from two peers on MEA 2. One peer feedback on the math model stated:

“They addressed it pretty well, just explain the SST a little more clearly.”

The team received this feedback on the math model from another peer:

“This method seems very complex to solve the problem but does solve it with complexities.”

The team agreed that one of the two peers did not provide useful feedback. Three team members, Ryan, Sam, and Jerry believed the second was not useful either. Jerry stated:

“Both of our feedbacks were, at best sub par. I mean, … neither of them took much time. They had, like, one sentence written in each thing. And then… neither of them did the actual mathematical model to find the solution in the new, the new set of data. So, we didn’t really get much out of the student feedback this time. It was real lacking, more so
than last time 'cause last time one wasn't good but the other was really de-- pretty good and this time it was just both of them were very unhelpful.”

Ryan agreed:
“We got two really bad sets of feedback this time. Last time it was just one and one really good one. This time neither one performed our mathematical model, even though it was possible. Like one said there was no data to perform it for, but they just missed clicking on the link or didn’t try to. And the second one just copied our data from the first time that we ranked our top four, but then the new set of data had like eight companies and they were completely different, but they just kind of rewrote what we said and said, “Yeah, it checks.” So they obviously didn’t spend any time trying to figure that out either. And both teams kind of just... When it says, “Describe in 3-5 sentences,” it was like half of a sentence or a sentence poorly structured, and they just kind of agreed. They were kind of like, “Oh, yep, this is good.” There was no critical analysis or suggestions really—or logical suggestions.”

In contrast, Dave thought one of the peer’s feedback received was helpful. Dave described the peer feedback, going as far as to state the peer feedback was more helpful than their GTA feedback:
“One of them was almost nothing. I think we got two peer critiques and one of them pretty much didn't give us anything to work with. And the other was decent. I think that we really based most of our changing on our drafts off of that one rather than the TA feedback.”

Pairing with their opinion that the peer feedback was not helpful, students Ryan, Sam, and Jerry stated the team did not make changes based upon the peer feedback. Sam stated:
“Well, the lack of material kind of made it so that you couldn't use it. Yeah. There was nothing there.”

When asked about their team’s response to the peer feedback, Ryan said:
“How did we respond? We were just kind of mad. We were kind of like, “OK, well, let’s just see how we can follow the TA’s model even better.”

Jerry described the team’s response.
“We read through it and then realized that the people that did it really didn't even read ours... a lot of it was just, like, this is great, this is good, you did a good job, good. Well, you can’t really respond if they just say everything is good. You have nothing to really change. So, I think there was one thing that we changed off of it, but I can't even remember what -- it was something really little that the kid pointed out. But other than that, it was -- we couldn’t really do much with the feedback.”

Dave believed the team made changes based upon the better of the two peer feedbacks.
“I think a lot of what we responded to the peer feedback was the, I guess, the sharability and like, how adaptable it was to other people that didn't really know exactly what we were trying to say.”
Peer Feedback on MEA 3

The team received feedback from three peers on MEA 3. One peer gave the following feedback on the math model of this MEA:

“There are a few places where explanations are needed. why did you leave out the frequency of the bus in your conditions? The bus stop may be close but it may not come at a convenient time...would the student still take the bus? Also, while the cost of auto is given as a variable in the start, it is not used anywhere in your conditional statements. Why did you decide to leave this information out? If the car and bus are equally convenient and the bus costs $1 and parking costs $100, would they drive or take the bus? Your procedure in some situations says the student will drive even though it is much more expensive.”

The team received this feedback on the math model from another peer:

“Some steps overlap, such as if the bus stop is .5, the bus costs 0, and the walking time is 10.”

The team’s third feedback on the math model stated:

“The overall complexity of the problem is fairly well addressed. All data is accounted for in your procedure.”

The team agreed the peer feedback on MEA 3 was okay at its’ best, but was primarily not helpful. When asked to describe the peer feedback, Sam stated:

“Again, vague. Not very specific. Not very useful. It was mostly us going back through old MEAs and picking out what our TA said about those and how we got scored at the end.”

Dave reiterated the lack of help the peer feedback provided:

“The feedback that we got for this one, I think should have said everyone's just kind of getting tired of it because it didn't, like, there was nothing there. There was one where literally all their comments were no comment or none. They just didn't put any effort into it. And the ones that actually did make comments, didn't really give anything helpful.”

The team made little changes based upon the feedback. Dave commented on the changes made:

“One of them just kind of showed that, like, the kid was kind of confused with our procedure and so I guess that, that helped us improve the clarity of it, just because, like, to us it seemed obvious because we wrote it but other people maybe didn't understand it as well.”

Jerry discussed their response:

“At this point we kind of lowered our expectations for the student feedback considerably. We just pretty much decided that when we have our meeting for the peer feedback session we would basically just talk with ourselves, run over everything one more time, just keep looking at our thing -- as -- the more you look at something you're gonna find, like, little details that you missed so that's mainly what our second meeting was about usually rather than addressing what the peer, our peers would say.”
Sam also discussed their response to the peer feedback:

“We laughed. And we just looked at other things in the rubric again and re-evaluated it ourselves, since they were useless.”

Although the peer feedback they received was not helpful, team members pointed out that it was helpful to them to give feedback to their peers. Dave stated:

“I think that giving peer feedback was more helpful than getting it, actually. So we could see what the other groups are doing and compare that to ours.”

IV. Discussion & Implications

The purpose of examining this case study was to understand this particular team’s experiences as a unique entity. As suggested by Patton, a case study should take the reader into the situation and should stand alone as an individual demonstration of the phenomenon of interest\(^\text{12}\). The students on this team unanimously agreed the GTA feedback they received was the most helpful component of the MEA implementation. This aligns with the research of Falchikov and Goldfinch who found peer assessment in professional practice exercises did not correspond well to instructor assessments\(^\text{13}\). Students on this team also agreed that the GTA feedback helped them improve their MEA solutions. The GTA was viewed as an expert and was respected due to their expertise and their role as the grader. Although the students respected and made changes to their solution based upon GTA feedback, they desired to have feedback from their GTA that was specific to their MEA solution. The students had contradictory perceptions of the level of specificity and vagueness in the GTA feedback. General feedback, or cut and pasted comments, was not helpful to this team. The GTA for this particular team chose to give generic feedback some members of the team perceived as vague. The GTA comments made on the mathematical model were largely cut-and-paste from the GTA grading guide and could have been applied to any MEA solution. The grading guide was intended to be a reference point for the GTAs to help them formulate feedback to direct students from their current model to a higher quality model. This team’s GTA put very little thought into how the grading guide materials could be applied to the student team’s models. As a result, the students were given the answer for how to construct a high quality model for each MEA. Because the team was unaware of this, they were left to interpret what the GTA feedback meant in relation to their current model. The GTA feedback received by this team suggests additional research is needed on training methods to improve the specificity of TA feedback and the impact it would have on the quality of student solutions. In addition, future research will compare and contrast the GTA feedback received by this team and its’ affect on student solutions with the feedback received by other teams.

The team struggled with the feedback received from their peers. Although some of the feedback received was helpful, much of the feedback from their peers was not useful in revising their solutions. The team expressed frustration at the fact many of their peers did not put much effort into the feedback they gave. While some of the students gave feedback that helped the team clarify the math model, a large portion of the peer feedback consisted of one or two sentences. The content of this brief feedback was not helpful and made statements such as all of the data being accounted for. It revealed that the peers did not review the solution. These peer review results are consistent findings in our research and with that of others. Peers place a lower value
on feedback from peers than instructors. Even though students do not value the feedback of their peers, participation in the review process is helpful to students. Studies have shown that engaging in peer review is valued by participants and the process of providing a peer review can help students improve their own work.\textsuperscript{15, 16}

Diefes-Dux & Verleger noted that between 25 and 35 percent of the class failed to participate in peer review on any given MEA in Fall 2008\textsuperscript{3}. This means that the quantity and variety of feedback student teams receive is compromised. And while those peers that did participate felt comfortable and capable of giving reviews, students rated the “fairness & accuracy” of the reviews and whether the reviews “resulted in change” slightly lower. Finding ways to hold students accountable for completing peer review and proving good-faith effort reviews is a challenge. Certainly one can check that the peer review is complete and provide credit for that. However, completion is not an indicator of quality. To grade 1200 student peer reviews for quality is taxing on instructional staff because instructors have to interpret not only the reviews but the student work being reviewed. To some extent we have relied on students reviews of the peer reviews, but this is problematic too. Sometimes students do not recognize a good review, particularly if it is harsh or highly sophisticated, or they don’t care that they got a bad review, or they were satisfied that they heard what they wanted to hear. This raises questions about the validity of students’ assessment of their reviewers. Future research will examine the peer reviews received by other teams. Quality peer reviews will be examined to determine what kinds of peer comments are helpful and the impact they have on student solutions.

Acknowledgements

This work was made possible by a grant from the National Science Foundation (EEC 0835873). 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 would also like to thank the students who participated in this study as well as Mark Carnes, Amani Salim, Raghavi Meruguredy, and Xiang Gong for their comments and feedback, and Amber Oliver for her contributions to the data collection.

Bibliography

APPENDIX A: STUDENT INTERVIEW PROTOCOL

The purpose of this interview is to reflect on your attempts to give feedback to your peers on their work and to reflect on your attempts to respond to feedback you have received from both your peers and your TAs. Your feedback is very important for helping us to improve our understanding of how people learn to give and receive feedback to mathematical modeling problems and for helping improve future instruction and learning activities. This interview will take approximately 30 minutes. All your responses to my questions will be recorded and later transcribed. At no time will I identify your actual name in the recording of your responses during this or any other interview. I will assign a pseudonym to your responses, and I will store and label all the recordings with the pseudonym.

Part I: Experiences responding to feedback
First I will be talking with you about your experiences in responding to feedback you received from your peers and your TAs.

1. Can you please describe for me the type of feedback that you received from your TA?

2. How did your team respond to this feedback? Would you have done anything differently if you were responding by yourself?

3. Did you encounter any challenges in responding to the feedback from your TA? If yes, How did you work around these challenges?

4. [Specific question based on video of team responding to the feedback]

5. Can you please describe for me the type of feedback that you received from your classmates?

6. How did your team respond to this feedback? Would you have done anything differently if you were responding by yourself?

7. Did you encounter any challenges in responding to the feedback from your classmates? If yes, How did you work around these challenges?

8. [Specific question based on video of team responding to the feedback]

Part II: Experiences providing feedback
Now I will be talking with you about your experiences in providing feedback to another team on their MEA response.

9. What kinds of feedback did you provide to another team? Probe: emphasis on mathematical model vs. reusability/sharability vs. meeting client’s need

10. Did you encounter in any challenges in trying to provide feedback to your peers on their model-eliciting activities? If so, please describe them.
11. How did you work around these challenges?

12. Can you think of anything that would have helped you to give better feedback to your peers?

III. Experiences in Responding to / Receiving Feedback on the Feedback Given
The final activity you did for the Model-Eliciting Activity was to give feedback to your peer reviewers on the feedback they provided you. I will now talk with you about giving and receiving this feedback.

13. Is there anything that you decided not to mention in the feedback you gave to your peer reviewer?

14. Did the feedback you received about your feedback help you?
## APPENDIX B: MEA RUBRIC WITH THREE DIMENSIONS

<table>
<thead>
<tr>
<th>Dim.</th>
<th>Item Label</th>
<th>Full Item Wording</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>No Progress</strong></td>
<td>No progress has been made in developing a model. Nothing has been produced that even resembles a poor mathematical model. For example, simply rewriting the question or writing a &quot;chatty&quot; letter to the client does not constitute turning in a product.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>False</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td><strong>Mathematical Model Complexity</strong></td>
<td>The procedure fully addresses the complexity of the problem.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A procedure moderately addresses the complexity of the problem or contains embedded errors.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A procedure somewhat addresses the complexity of the problem or contains embedded errors.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does not achieve the above level.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td><strong>Data Usage</strong></td>
<td>The procedure takes into account all types of data provided to generate results OR justifies not using some of the data types provided.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Rationales</strong></td>
<td>The procedure is supported with rationales for critical steps in the procedure.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Provide Written Feedback About the Mathematical Model Here:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Re-Usability/Modifiability</strong></td>
<td>The procedure not only works for the data provided but is clearly re-usable and modifiable. Re-usability and modifiability are made clear by well articulated steps and clearly discussed assumptions about the situation and the types of data to which the procedure can be applied.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The procedure works for the data provided and might be re-usable and modifiable, but it is unclear whether the procedure is re-usable and modifiable because assumptions about the situation and/or the types of data that the procedure can be applied to are not clear or not provided.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does not achieve the above level.</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Provide Written Feedback about Re-Usability and Modifiability Here:</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Audience (Share-ability)

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>True</th>
<th>False</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Results from applying the procedure to the data provided are presented in the form requested.</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Audience Readability</td>
<td>The procedure is easy for the client to understand and replicate. All steps in the procedure are clearly and completely articulated.</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>The procedure is relatively easy for the client to understand and replicate. One or more of the following are needed to improve the procedure: (1) two or more steps must be written more clearly and/or (2) additional description, example calculations using the data provided, or intermediate results from the data provided are needed to clarify the steps.</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Extraneous Information</td>
<td>There is no extraneous information in the response.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Provide Written Feedback About Audience (Share-ability) Here:

**Overall Assessment is the lowest score on any rubric item.**