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Work in Progress: Using the Formative Assessment Enactment Model to Characterize Instructor Moves in a Learning-Assistant Supported Mechanics Course

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The LA model, developed by the University of Colorado- Boulder, has been gaining momentum in engineering departments [1]–[4]. LAs are undergraduate students who facilitate student thinking and encourage inclusive active learning in the classroom. They participate in weekly preparation sessions with their supervising faculty, where they provide input as active members of the instructional team for their course. A key distinction between LAs and TAs is that LAs participate in a pedagogical training program and typically do not partake in the grading process [5]. This creates opportunities for students to express confusions and ideas without fear of negative impact on their course grade. Research is needed to explore the types of moves that LAs use to enable these discussions of ideas. Overall, in seeking to characterize LA work and begin to understand how it compares with professor work "in-the-moment" in an engineering classroom activity, we take the perspective that supporting students as they work on a task is an act of continuous formative assessment [6].

This study compares the moves made by an LA and a professor to support students in an introductory statics and strengths of materials course at a small private university in the northeastern US. For the particular class session at the focus of this study, the students had been assigned for homework an open ended modeling problem focused on a weight-bearing structure [7]. During the class session, the students met in small groups to compare their individual solutions and work together to make a group model of the structure. LAs and the professor visited the groups as they worked. The central question for this study is: What instructional moves are mechanical engineering learning assistants and professors using when they interact with students working in small groups in an engineering science class?

Framework

We draw on the formative assessment enactment model (FAEM) to guide this study's analysis of instructor moves [8]. Dini et al created the FAEM because they wanted to characterize the ways in which instructors enact formative assessment and help instructors name what they are doing in their classrooms. They used the FAEM to look at the goal of instructor moves with respect to student thinking – that is, to describe whether a move is used to *advance*, *interpret*, and *elicit* student thinking. *Eliciting* involves figuring out what a student already knows and thinks, while *advancing* involves moving students toward particular learning goals. *Interpreting* involves processing student responses and statements to understand the student's reasoning from their point of view and determine what support they need next. In addition to classifying the goal of a move as advancing, interpreting, or eliciting, the FAEM also characterizes how *authoritative* or *dialogic* instructors are with these moves. *Authoritative* moves involve placing one particular interpretation (e.g. canonical science) at the center of the discussion. *Dialogic* moves involve broadening the perspectives of the students by providing space for argumentation or advancing in a responsive way to what students are thinking.

Data Collection

The setting for this study was an introductory level mechanics course. For the particular class session at the focus of this study, the students were given an open ended modeling problem [7] to do before class as a homework assignment. The problem entailed students modeling different attributes of the iWalk, a hands-free crutch, and making assumptions about the model (see Appendix). The main goal was to determine the maximum axial load on component AB (the major column in the lower half of the crutch). During the class session, the students discussed and compared their individual solutions with an assigned group and then worked together to make a group model.

With IRB approval, we collected audio recordings from 12 consenting groups across two sections of the course for the 75-minute class session. Groups had 3 or 4 students, for a total of 47 student participants. One professor and the LAs (LA1 for the morning section, LA1 and LA2 for the afternoon section) circulated the room to check in, converse with groups, and respond to questions. Instructor visits to groups ranged from LA1 and LA2 were both in their first semester in the LA program.

Analysis

We transcribed the audio recordings and analyzed the transcripts using a codebook adapted from the framework presented in the FAEM [8]. Dini's team evaluated *interpreting* in terms of entire episodes, whereas we used *interpreting* on individual moves where the instructor is voicing an aspect of the interpreting spectrum. We made this decision because there were instances that the instructors voiced interpretations while in conversation with the students which seemed on a similar scale to the *eliciting* and *advancing* moves. The coding scheme, which can be seen in Table 1, was applied to all instructor (professor and LA) turns of talk by the first author. The second author reviewed code applications and where there was disagreement, we conferred until reaching consensus.

Code	Authoritative	Dialogic
Eliciting	Narrow Eliciting- questioning students to get at their thinking about particular details or aspects of the problem.	Open Eliciting- questioning students to find their current thoughts on broader aspects of the problem or providing room for argumentation.
Interpreting	Evaluative Interpreting- indicating the correctness of a student's thoughts or ideas and how they compare to the canonical solution or the instructor's viewpoint.	Inferential Interpreting- hearing the underlying assumptions of student thinking and revoicing or attending to students' feelings around the problem.
Advancing	Directive Advancing- guiding students down a particular path of reasoning or explaining a concept.	Responsive Advancing- using what students have said to create opportunities for reasoning and moving their thinking further.

Table 1. FAEM Coding Scheme

Findings

In the findings, we describe overall trends in the quantity and nature of interactions between instructors and students as they discussed the iWalk problem.

Use of both authoritative and dialogic moves. At its highest level, the instructor talk move coding scheme distinguishes between two main kinds of moves – authoritative and dialogic. Overall, across both class sessions and all instructors, of the 445 moves, 44% (196 moves) were authoritative while 31% (138 moves) were dialogic and 25% (111 moves) were uncoded (usually an indicator of listening or an off-topic discussion). This result means that from the LAs and instructor combined, students in the session experienced discussion that centered one perspective more often than they received discussion that encouraged or provided different perspectives, though both occurred in substantial amounts.

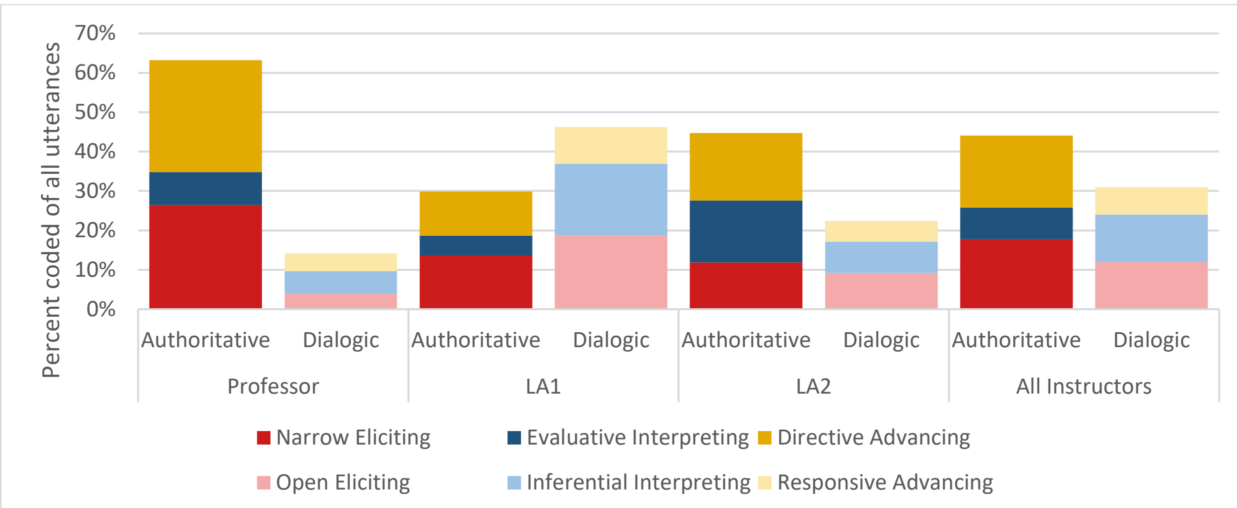

Figure 1: The distribution of authoritative and dialogic moves by instructor.

If we disaggregate by instructor, we see that the majority of the authoritative moves were proportionally made by the professor whereas the majority of the dialogic moves were made by LA1. The professor used authoritative moves roughly 4.5 times more often than dialogic moves, while LA1 used dialogic moves about 1.5 times for frequently than authoritative moves. Finally, LA2 used authoritative moves about twice as often as dialogic moves.

Detailed categorization of talk moves, compared across instructors. Beneath the authoritative vs dialogic distinction, we coded for narrow eliciting, evaluative interpreting, and directive advancing authoritative moves and open eliciting, inferential interpreting, and responsive advancing dialogic moves. Each instructor had a different pattern of relative frequencies of these kinds of moves.

Professor's move distribution

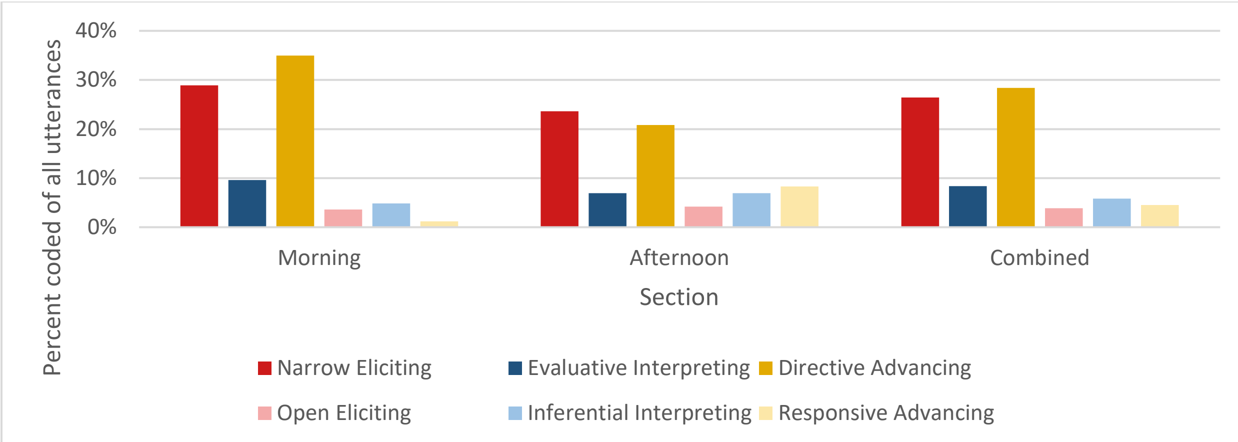

Figure 2: Professor's move distribution.

The professor tended to be the most authoritative in her talk with student groups. Within the professor's authoritative moves, most were evenly split between narrow eliciting and directive advancing. An example of narrow eliciting is, "Just curious, you're considering your body weight to be at Point B?" This quote is an example of narrow eliciting because the professor is asking students about a specific aspect of their design choices and giving a possible answer within the question. An example of directive advancing is, "Just one observation here, so remember when you drew a free body diagram and you had like a distributed load, how did you- did you put the resultant force on there or just like the distributed load itself? Remember from like homework problems and stuff when you had distributed loads and then you wanted to draw the free body diagram?" This quote is an example of advancing because she is pointing them on a path to move forward. It falls into the directive category because she is using rhetorical questioning to remind the students of a different homework problem and the procedure that they used there.

This pattern held across morning and afternoon sections. That is, while there was a small shift in which was higher between the morning and afternoon, narrow eliciting and directive advancing were still significantly higher than any of the other categories.

LA1's move distribution

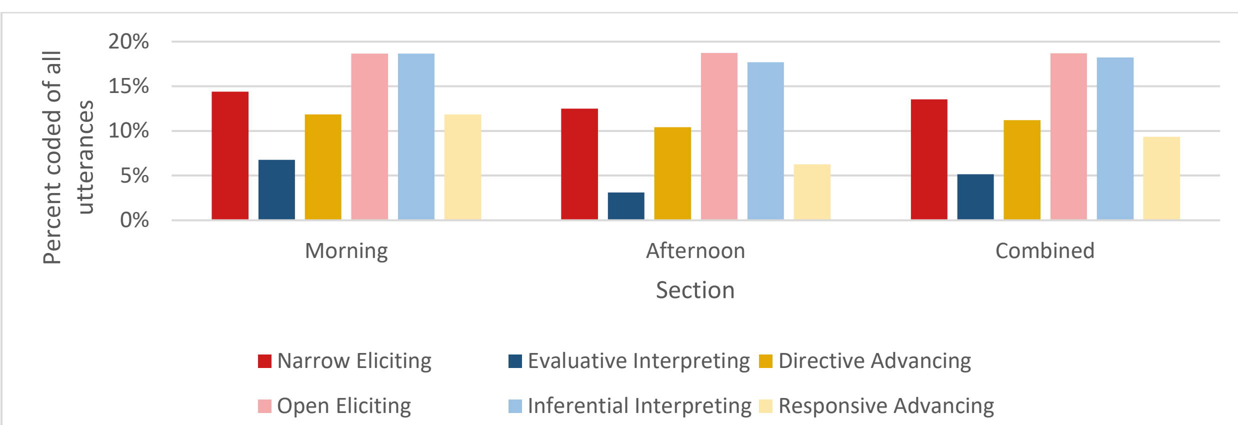

Figure 3: LA1's move distribution.

LA1 had the most dialogic moves of the instructional team. Within LA1's dialogic moves, most were evenly split between open eliciting and inferential interpreting. An example of open eliciting is, "How's it going in terms of deciding on assumptions?" This move is open because there are many possible directions in which students could take this up and eliciting because the LA is getting at what the students are currently thinking. An example of inferential interpreting is, "Just wanna make sure you guys are in a good place still". LA1 was attending to how the group is feeling about their progress in the problem and their learning. She seemed to be anticipating that the group may need some help but was leaving it open for them to bring up anything.

Additionally, LA1 had the highest frequency of responsive advancing moves of the instructional team (9% for LA1 vs 5% for professor and LA2). An example of this move is, "What do you guys think are like the benefits of having like a higher factor of safety versus a lower one?" The students had brought up the idea of factor of safety, and LA1 responded by pushing the students to think about the possible different effects of different decisions about safety factor.

LA2's move distribution

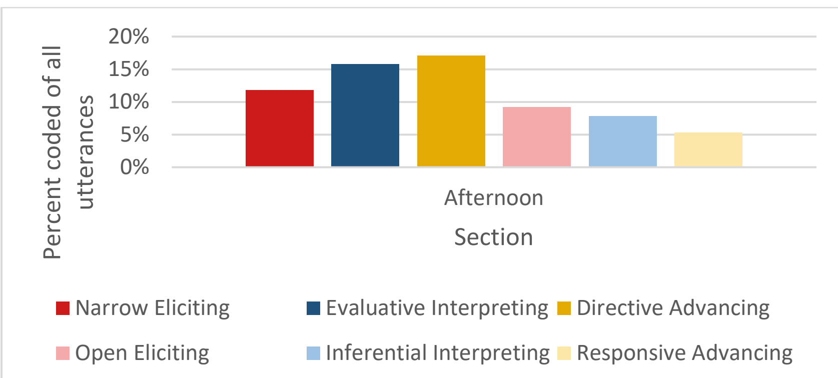

Figure 4: LA2's move distribution.

LA2 only participated in the afternoon section. LA2 tended to have slightly more authoritative moves than dialogic moves. She mostly had directive advancing and evaluative interpreting moves. An example of one of her directive advancing moves is, "You can just multiply the whole thing by 4 and be good. Area is pi R squared, it would be pi over 4 D squared, right." This fits the directive advancing code because she is reminding students of connecting radius to diameter when finding the area of a circular cross-section. Within the evaluative interpreting category, LA2 responded to students utterances with "Right", "Good", or "Great" 8 times. These were evaluative interpreting because it can signal to the students that they are correct in what they are saying.

Conclusion

The professor used more authoritative moves than either of the learning assistants, specifically authoritative eliciting and advancing. LA1 was particularly dialogic in her discourse and specifically used dialogic eliciting and interpreting moves the most. She was also the most frequent user of dialogic advancing, however this was the lowest category used overall. LA2 seemed to be a blend of the other two instructors but used authoritative interpreting and advancing moves the most frequently. Future work will examine the use of different moves in the context of the student conversations and consider how time may factor into the types of moves the instructors use.

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Appendix

Open-Ended Modeling Problem (Mechanics)

The iWalker 2, a hands-free crutch, is an example of one of the many assistive devices used to help people with lower leg injuries live their life more comfortably.

The main advantage of this device is that it lets the person use both hands freely, which is not possible while using traditional crutches or knee scooters.

We are going to analyze this hands-free crutch throughout the class. Because this is your first mechanics course, we have to make certain assumptions and simplifications in order to have an analysis that you can complete. It is important to document all the assumptions and think about ways you can improve them.

There are two parts in this assignment:

- A written part which is due on October 28, at 12:00 am. You will be answering the questions at the end of this document. This part is worth 70 points.

- A small-group discussion part during class on October 28. You need to bring a copy of your written work to this discussion. You will be working with a small group of other students to compare your models of the hands-free crutch and develop a group model that's better than any individual model. This part is worth 30 points.

Model 1: The main bar supporting the weight of the person

When a person walks with a hands-free crutch, its base touches the ground and supports the weight of the person along with other forces that may develop during stance phase of the gait (Figure 1). Stance phase is a phase of during which the foot remains in contact with the ground. To simplify the calculation, we will experiment with a simplified 2D model of the device as shown in figure 2.

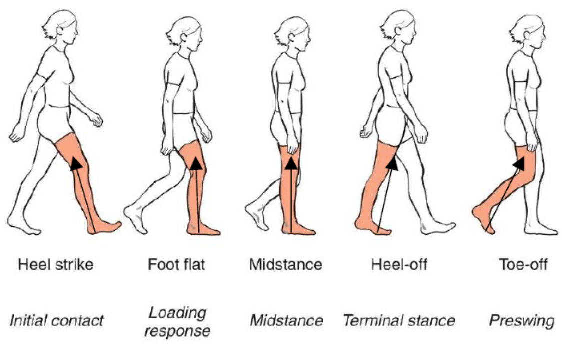

Figure 1. The stance phase of human gait, the arrows show the ground reaction force

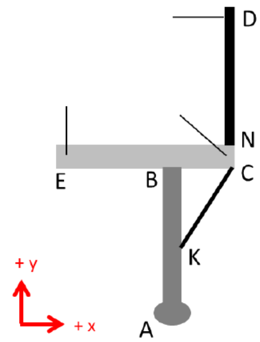

Figure 2. Simplified 2D model of the hands-free crutch

Assume that the origin of the system is at A, with +x going to the right and +y going up. Also assume that angles are measured from the +x axis, with + angles going counterclockwise. So, for example, a force that's in the +y direction is at an angle of 90°, while a force that's in the –y direction is at an angle of –90°.

Other assumptions you can make to simplify the problem:

- Straps at D, C, and E are looped cables with zero tension during stance phase.
- Member CK is connected to EC and AB through smooth pins.
- Member DN is welded to member EC.
- Member AB has circular cross-section and is massless.
- Human body segments can be considered rigid members.

You will also need to:

- Choose the type of connection that the device makes with the ground which best describes the real scenario.
- Choose the type of connection at point B. The connection of member AB to EC at point B can be either be through smooth pin or welded. Think about how your choice can impact the loading on member AB.

Your task:

Imagine that you are the designer and want to find the proper material and size for member AB that provides enough support while it is used for walking on flat surface only. To do so, you need to do force analysis and make further assumptions about the structure of the device. Remember to consider the instant during the stance phase that you think puts the highest load on member AB.

Answer the following questions if the hands-free crutch is being used by a person weighing 125 kg (weight capacity of the device) and having a height of 175 cm:

1. (15 points) Make a qualitative (i.e. no numbers) free-body diagram of the whole device (DN, EBC, CK, and AB together) **and** free-body diagrams of each member (DN, EBC, CK, and AB) separately. You need to draw all forces and moments that are acting on the system. You may want to consider forces such as:

    - The weight of each member
    - The load the user places on the crutch

    However, this is certainly not an exhaustive list! For this part, you should clearly label each force/moment and each important dimension with a variable name, but you should not put any numbers on this free-body diagram.

2. (10 points) Calculate the value of each force, moment, and dimension in your free-body diagrams. Make a table clearly showing the variable name, its value (with units), its direction (remember, + angles are counterclockwise from the +x axis), and its x- and y-location from the origin. An example table is shown below:

Force / Moment	Variable	Value	Direction	x-Location	y-Location
Weight of member EBC	W_{EBD}	1,000,000 kg	–90°	2 m	4 m
…	…	…	…	…	…

3. (15 points) Specify any assumptions and simplifications you made in drawing the free-body diagram of the system and calculating the values of forces, moments, and dimensions. Also, if you used any references to determine values or assumptions, please cite these here.

4. (12 points) Compute the maximum **axial load** on member AB using the free-body diagrams and equations of equilibrium.

5. (10 points) Using the material properties table provided and the axial load on member AB that you just computed, select a material and diameter for the member AB that you believe is enough given the yield stress of the chosen material. Justify your answer. Is the size of the bar you found physically reasonable? Why or why not?

6. (3 points) In question 5 you computed the size of the member AB based on the axial loading. What other forces/moments do you think might influence our choice of size and material for member AB?

7. (5 points) We modeled the crutch for walking on a flat surface. What would change if you it is used for walking up and down a hill? Would that change the load and therefore your choice of size and material?
    - You don't necessarily have to do any computations, just explain how the answer would change. Try to use equations to prove that the change occurs in a certain direction, but you don't need to do numerical calculations.

Bonus question (5 points):

Calculate axial load on member CK. How would you expect this value to change if you chose a different type of connection at point B?