

Troubleshooting Formative Feedback in P³ (A group-based learning environment)

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An important focus of the projects and practices in physics (P³) classroom at Michigan State University (MSU) is the development of scientific practices. However, it is very difficult for students to learn scientific practices such as communicating scientific information or constructive argumentation without feedback based on social interactions involving these practices. In the P³ class week, students are provided with written feedback based on observations by an instructor that is aimed at guiding the students in the appropriation of scientific practices. Through interviews, we examine student's reflections on their interpretation of the purpose of the feedback and what effect if any it had on their participation. By understanding how students respond to certain feedback, we can operationalize and improve the feedback that we give to students.

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I. INTRODUCTION

A crucial part of the design of a learning environment is the extent to which the students participating in the environment receive timely and informed feedback [1]. As college level physics classes transform to be more active-learning, group-orientated learning environments with a focus on appropriating scientific practices, the type of feedback students require is changing. Feedback communicated through grades on homework assignments, various types of continuous assessment, and exams is useful for informing a student of how they are doing in a class. However, this type of feedback tends not be overly formative in reference to new types of challenges students face in a transformed classroom-it does not focus on informing the student about how they might go about modifying their thinking or behavior to improve their learning in the classroom [2]. This gap in formative assessment is especially true in regards to learning goals that are often considered a part of the hidden curriculum of a transformed physics classroom (e.g., learning to work in a group productively).

In a new introductory mechanics class at MSU, individualized formative feedback has been implemented to evaluate an individual's contribution to their group and the development of their personal understanding. The feedback is designed to provide the students with constructive commentary on how they might improve within the class. As part of the evaluation of each iteration of the class, the design team have used action research to investigate, through interviews, students' perceptions of this type of assessment. Although mostly positive, students perceptions did highlight perceived problems with the formative feedback. The paper focuses on these problems and our design team's proposals to address them.

II. DATA SOURCE AND CONTEXT

Projects and Practices in Physics (P³) is a new introductory mechanics course at MSU, piloted in the fall of 2014 and offered again in the spring of 2015. In its first iteration, it was staffed by 2 faculty members, 1 post-doc, and 1 grad student and enrolled 40 students. For the first two iterations of the course the demographics of the student population tended to towards sophomore and junior engineering students. We believe that there is a lack of freshman due to advanced registration being offered to sophomore, juniors and seniors. It aims to engage students in science practice through the use of modeling projects. The students are required to negotiate meaning in small groups, develop a shared vision for their group's approach, and employ scientific practices to navigate their projects successfully. Groups' projects are sufficiently complex that students must make use of both analytical and computational techniques.

The P³ learning environment is designed so that the majority of the physics learning occurs while the students work in small groups within the classroom. Under the principle of constructive alignment [3], a learning activity should be designed so that there are clear, related learning outcomes for the activity and appropriate assessment for giving feedback to the learner. To provide this feedback and to motivate the students to engage in the in-class project activities, the design team designed the assessment so that 20% of a student's overall grade would be based on in-class work. It is communicated to the students through both a presentation on their induction day and through documentation that the in-class assessment is based on following three different categories:

- How well do you develop your own understanding of the physics (Individual Understanding)?
- How well does your group ensure all members develop an understanding of the physics (Group Understanding)?

- How well does your group manage itself in terms of the discussion and use of ideas (Group Focus)?

Descriptions of these categories are available to the students through documentation on the course website. The categories are scored on a 4.0 scale and the 3 scores are averaged together using weight factors that play to the strengths the students start the class with. In the grade for a student for the week, their highest category score comprises of 1/2 of their overall score, the next highest will comprise 1/3, and the lowest will comprise 1/6. At the end of the semester the students drop their two lowest week grades and the remaining grades make up 20% of a student's overall grade in the class.

Instructors provide the students with written feedback before the start of each new project. We have provided an example of the type of feedback the students received (Fig. 1).

Instructor feedback is based on the previous weeks' project performance and focuses on one type of participation that they excelled at and one type to work on in the next project. The feedback provides the students with suggestions on how they might go about achieving that improvement. They also discuss group functioning as a whole to attempt to facilitate good group dynamics.

III. RESEARCH METHODOLOGY

The design team for P³ had not previously implemented a formative feedback assessment approach as described in the previous section. Given this lack of experi-

Week 7 Feedback: Aoife

Again, your group did a great job working together. You all worked through both problems well and had good discussions about the physics in the problems were it was clear that each person's ideas were respected and valued. This week it's clear that you all listened to the feedback as Sean, Niamh, and Cliona were all contributing to the intellectual work in the problem most of the time. You seemed to be included for most of the work, but sometimes it seemed like they were working on something and then catching you up. Maybe shake up the seating order to put yourself in the middle so you can contribute more; your questions help your group think about problems in new ways. So next week we'd like to see you try to insert yourself into the group work throughout the week. Also, Aoife, we'd really like to see you question different aspects of the work – you seem to have a critical eye when something is fishy, but you don't often express it. But, y'all did a great job again!

Group Understanding (out of 4): 3.5
Group Focus (out of 4): 3.75
Individual Understanding (out of 4): 3
Weekly Group Work Score (out of 4): 3.54

FIG. 1. Sample feedback received by students in P³.

ence, the team wanted to be ready to tackle any problems that arose from the utilization of formative feedback as an assessment tool. The aim of an action research methodology is to allow both the action researchers and members of the social setting being investigated to collaborate in the identification of problems [4]. Co-identification also facilitates co-solving of the problems identified. The action research approach the P³ design team employed was based on 3 assumptions:

- The design team is interested in improving their practice and wants to create a learning environment that addresses the needs of their students.
- Reflection on one's teaching and learning environment design can facilitate improvements in one's teaching and assessment.
- Students are a fundamental part of the education process and therefore are worth listening to.

For this project, the last assumption is key to the research outlined in this paper. It is fitting that research focused on how to improve feedback given to students be informed by the feedback given to us from the students. Therefore, in the context of this study, students' perceptions of their experiences with the formative feedback may provide the design team with valuable insights into making improvements with the assessment system. The action research approach to improving the P³ learning environment involved members of the research group at MSU conducting semi-structured interviews of 9 students. The interviews took place either at the end of the semester that the student was in P³ or at the beginning of the next semester.

The initial analysis consisted of identifying all of the feedback problems that the students indicated in their interviews and creating interpretive descriptions to detail the problems using extracts from the interviews as guidance. At this point, some of the problems identified by different students were easily interpretable as being the same (e.g. perceiving a difference in which instructor gave the feedback) and so were grouped together for the next stage of analysis. The focus of the action research approach is to inform one's teaching and so although several of the problems identified repeated across interviews, we are placing no significant importance on the prevalence of a problem in the presentation of our categories. The next step in the analysis process was to take the identified problems to the instructors of P³ and ask them, based on their experiences in the learning environment, which problems they interpreted as being priority concerns for the next iteration of the P³ learning environment. Once all priority problems had been identified, the problems were examined for recurrent themes and problems of a similar theme were placed into the same category. It is these categories that are presented in the analysis section below with extracts from the interview transcripts presented to give substance and support to the descriptions of the categories. The following section outlines the categories identified through this analysis process.

IV. ANALYSIS

A. Category 1: Problems with Feedback Comments

The students identified three main problems with the feedback comments: they were dependent on the instructor assigned to their group; they needed to be personal; and they tended to plateau over time.

Dependent on Instructor: The first semesters of the P³ learning environment had four instructors grading between 2 and 3 groups every week. Each instructor would work with the same groups for 4 weeks. After this 4 week period, the students making up each group were rearranged so each individual student would be in a new group working with new students. After this rearrangement of groups, an instructor would typically be assigned to groups that she had not worked with before. Given this structure, students in the class often worked with at least 3 different instructors during the class. Students identified the experience of working with different instructors significant in relation to the feedback:

Aoife: *I think there was a huge difference between who gave me the feedback, like I felt like some instructors gave us more constructive feedback*

The instructors agreed with Aoife that there was a significant difference between who gave the feedback and that instructors often focused on different aspects of the classroom to improve on. It is worth noting though that students perceptions of constructive feedback will be dependent on what students view as constructive to the goals they are trying to achieve. For example, feedback from an instructor that consistently focused on creating a harmonious group could be construed as being unimportant by a student who does not value group harmony. In the case of Aoife, as indicated in her later comment in this section, constructive to her often meant that the instructors should be more specific about instances of time when she participated successfully and unsuccessfully.

Too Broad to be Useful/Feedback should be more personal: Fundamentally “too broad” and “more personal” are a perception of the same problem, but from a different perspective. Broadness was often a feature of the feedback due to the constraints instructors were under to give personalized feedback for each individual group member in a hectic learning environment.

Aoife: *I feel like when it's way too broad or general, or it's not really specific, it's not really helpful because I don't really know what to do. And when it was like, you didn't help your, teammates, enough, yeah that makes sense but, when it's more personal, when you have that sentence you remember that you did, when you're telling me you did this and this, it's easier for me...when it's way too broad its like okay I have to fix this. But I don't know how.*

The above extract highlights that Aoife wants to fix the highlighted weakness, but has not been given enough de-

tail from the instructor to resolve the problem. Identifying broad problems without indicating specific instances is perceived as being more frustrating than helpful. Instructors may be highlighting a gap in a students' skills or approach and not offering enough scaffold to bridge it. Not all students are ready to be reflective to how they approach their learning and Aoife may be highlighting this by asking the instructors to reflect for her on specific instances so that she might understand how better to participate in the P³ learning environment.

The Feedback Comments Plateau Over Time: Students felt that the comments did not change significantly from week to week, and instead it encouraged them to work on the same weakness. Alternatively, a student would feel as though she had improved significantly on the weakness highlighted and wanted to improve in another area, but instructors would continue to focus on the same weakness. This focus lead to perceptions of repetition and, hence, the feedback plateauing over time. Saoirse outlines this phenomenon in the following extract:

Saoirse: *And also they did end up saying almost the same thing every week I felt like for a while, it kind of plateaued, I got my grades up for the weekly projects it was like you continue to improve but you still need to do this, it felt like the same comments every week after a while.*

For Saoirse, this feeling of plateauing may have originated in the fact that she only had 2 different instructors during her whole time in P³. This meant that all of her feedback was sourced from only two instructors, which when combined with the variety of feedback being dependent on instructor problem resulted in a plateauing of the feedback she received. Saoirse references getting her score up, which was a result of her attending to the comments she received at the beginning of the semester and showing an improvement. Saoirse then started to receive similar types of commentary on taking a more active role in leading her group and perceives accurately that this commentary repeats until the end of the semester. The instructors felt this was an important aspect of the learning environment for Saoirse to improve on but did not offer advice on how to modify her behavior to address this weakness. Saoirse's reference to score and it going up but the comments staying the same leads into the next category of problem: the feedback score.

B. Category 2: Problems with Feedback Score

The students perceived two main problems with feedback score: the commentary did not correlate with the score, and it felt like you could not improve on the score.

Feedback comments did not correlate with score: Students identified a problem that feedback commentary could be very positive and that it indicated that a student had improved from the previous week, but then their score would not have changed significantly between weeks.

Teresa: *I noticed in reading the feedback, the more positive comments that they left in the paragraph writing the lower my score was, I was like, you know I don't really see how these things correlate.*

The instructors felt that this was a priority problem because students will not pay attention to the feedback if it is sending mixed messages. The students should be able to observe the correlation between the commentary and the score. The assessment should also be as transparent as possible so that students are aware of how these two aspects of the feedback relate to each other.

Felt like I couldn't improve on it: A related problem in regards to perception of their score was the students' impression that no matter what they did in class they could not influence a significant overall change in their in-class grade. They indicated that they read the commentary, attempted to act on it to the best of their ability, and observed no change in the score that they were receiving.

Lucy: *I actually found those grades a little frustrating because I don't know how to improve them, I try to be more vocal about my opinions and ask more questions and then I feel like I still get the same grade.*

As indicated by the Lucy extract, a student could feel as though she did take steps based on their commentary to improve her score and still feel like she got the same grade. The category 2 problems highlight for the instructors a connection issue between the score and the comments within the feedback that prevents the student from perceiving the feedback as constructive. This lack of connection may lead to students dismissing feedback as they feel it is inaccurate or that if they do pay attention to it and act upon it, their action will be ignored.

V. DISCUSSION AND CONCLUSIONS

Following the action research methodology, the discussion will focus on the intended actions the design team are going to take to resolve the feedback problems perceived by the students and prioritized by the instructors for the next iteration of the P³ classroom.

The problems associated with category 1 indicate that we need provide all the instructors with training in how to facilitate and provide feedback for a group. As we have recorded different groups participating in the learning environment, in the future we can use video data as a source of reflection for instructors to learn. For example, we can use video data of Saoirse working in her group during the time period in which her feedback plateaued

to understand how the feedback could have been altered to provide more guidance. It also could provide insight into how the instructors' push to have her lead her group more could have been scaffolded more successfully by the instructor comments. We intend to create a group of exemplars of feedback commentary for new instructors that align with certain interactions in a group to scaffold instructors into producing consistent and accurate constructive commentary for students. We also must pay more attention to the rotation of the instructors so that if they continue to address different issues, we can ensure that all students are getting feedback aimed at these different learning goals. It would seem that "dependent on instructor" and the "plateau" categories displays an inconsistency in student observations with the two observations in conflict. This highlights the challenging nature of using student interviews as the sole source of a change in practices. Future research will attempt to triangulate between multiple sources including in-class observations.

We believe the problems associated with category 2 are issues that pertain to the way that the feedback score is presented. The two score related problems might be improved by changing the presentation score itself. We intend to introduce a historical feedback aspect to the feedback score so that students can more clearly see the progression they have made under their assigned instructor. So if an instructor has had the same group for 3 weeks when the students receive their feedback for the third week, it will include the scores for week 1 and week 2. By encouraging this reflection, we hope the students will realize that they are in fact progressing the majority of their time in the P³ learning environment. Another visual change we intend to make is to move from the 4.0 scale to a 0 to 100 scale so that it is more obvious when students achieve positive shifts in their feedback score. Future work will focus on broadening the discussion of formative feedback from the P³ learning environment to be more applicable to implementation beyond such a specialized environment. We have presented a prioritized list of problems associated with implementing this type of assessment for this environment but as we continue our research we hope to operationalize this type of feedback and the problems associated for the broader PER community. We would highlight that all the students interviewed found the feedback process to be valuable to helping them interact in the P³ learning environment and so this type of feedback should be considered when implementing learning environments that involve a significant shift in what is expected of the student.

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