Developing an Observation Protocol to Categorize Formative Assessment in Engineering Courses

Mr. Max William Blackburn, University of Michigan

Max Blackburn is a fourth year undergraduate Electrical Engineering student at the University of Michigan, focusing in Power systems and Energy. He is currently assisting Dr. Cynthia Finelli with research concerning the effects of flexible learning spaces and formative assessment techniques.

Dr. Aaron W. Johnson, University of Michigan

Aaron W. Johnson is a postdoctoral research fellow at the University of Michigan. He received his Ph.D. in Aeronautics and Astronautics from the Massachusetts Institute of Technology in 2014, after which he served as a postdoctoral research fellow at the Tufts University Center for Engineering Education and Outreach. Aaron also obtained a master's degree from MIT in 2010 and a bachelor's degree from the University of Michigan in 2008, both in aerospace engineering.

Dr. Cynthia J. Finelli, University of Michigan

Dr. Cynthia Finelli is Associate Professor of Electrical Engineering and Computer Science, Associate Professor of Education, and Director and Graduate Chair for Engineering Education Research Programs at University of Michigan (U-M). Dr. Finelli is a fellow in the American Society of Engineering Education, a Deputy Editor of the Journal for Engineering Education, an Associate Editor of the IEEE Transactions on Education, and past chair of the Educational Research and Methods Division of ASEE. She founded the Center for Research on Learning and Teaching in Engineering at U-M in 2003 and served as its Director for 12 years. Prior to joining U-M, Dr. Finelli was the Richard L. Terrell Professor of Excellence in Teaching, founding director of the Center for Excellence in Teaching and Learning, and associate professor of electrical engineering at Kettering University.

Dr. Finelli's current research interests include student resistance to active learning, faculty adoption of evidence-based teaching practices, the use of technology and innovative pedagogies on student learning and success, and the impact of a flexible classroom space on faculty teaching and student learning. She also led a project to develop a taxonomy for the field of engineering education research, and she was part of a team that studied ethical decision-making in engineering students.

WiP: Developing an Observation Protocol to Categorize Formative Assessment in Engineering Courses

Introduction

Student assessment is a necessary component of engineering education that gives instructors insight into their students' learning [1]. Two broad types of assessments include *summative assessment* and *formative assessment*. Summative assessments, such as quizzes or exams, generally occur infrequently and at the end of a particular unit or activity. Alternatively, formative assessment is ongoing and integrated into lessons. In formative assessment, instructors elicit and interpret evidence about student understanding and achievement, and they use this knowledge to make rapid adjustments to their teaching [2], [3].

One way in which instructors can engage in formative assessment is by interacting with students during class. However, it can be difficult for instructors to have substantial and meaningful interaction with students in large-enrollment engineering science courses that are traditionally lecture-based [4]. In these courses, instructors need to make intentional efforts to create time for students to display their thinking in meaningful ways, such as by asking questions of the instructor or discussing strategies for solving a particular problem with the instructor. The overarching research project of which this work is a part aims to investigate formative assessment in engineering education by answering three questions:

1. How do instructors implement formative assessment in large-enrollment courses?
2. How do students respond to different implementations of formative assessment?
3. How do instructors change their teaching based on the positive or negative feedback they receive from students through formative assessment?

This work-in-progress paper presents the development of a classroom observation protocol that allows researchers to categorize these aspects of formative assessment.

Conceptual Model of Formative Assessment

The conceptual model in Figure 1 demonstrates a hypothesized process of formative assessment. First, an instance of formative assessment is initiated by the instructor (first block). Then, one or more students respond to the formative assessment (second block), for example, by answering the instructor's question or by asking their own question. And finally, the instructor evaluates the student response and makes their own response (third block). This response may be brief (e.g. confirming that a student's answer is correct) or more involved (e.g. discussing *why* a student's answer is correct), and it may change the course of the lesson from what was previously planned (e.g. developing a new example problem on the fly to address a student's question). As signified by the feedback loop in Figure 1, the instructor's response may also involve initiating additional instances of formative assessment. This three-stage model of formative assessment may repeat multiple times throughout a class session, with frequent interaction between students and instructors.

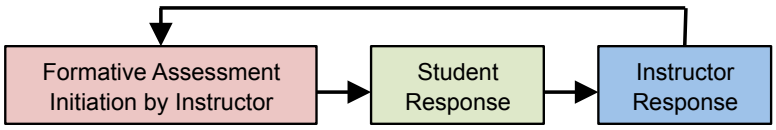

Figure 1. Three-stage conceptual model of formative assessment

Observation Protocol

This conceptual model serves as the basis for a standardized classroom observation protocol that will be used to characterize instances of formative assessment. A diagram of the observation protocol is shown in Figure 2. When a researcher using this protocol observes an instance of formative assessment, they first identify the type of formative assessment from among four options: 1) instructor asks student(s) questions, 2), student asks instructor questions, 3) instructor talks with individual student or group, or 4) instructor implements writing-based formative assessment. Then, the researcher chooses a response for each code (i.e. each colored box in Figure 2) describing the student and instructor behaviors in that type of formative assessment.

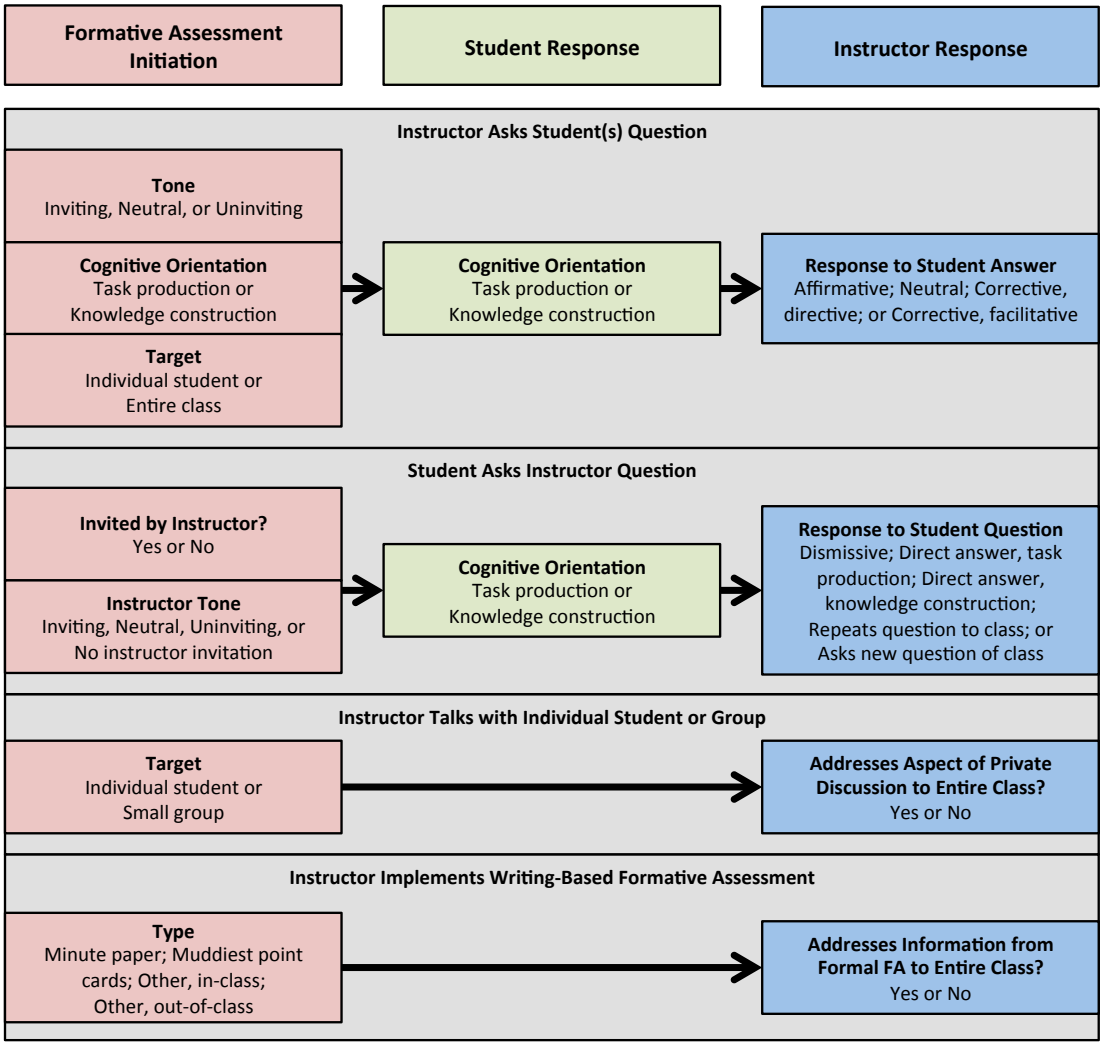

Figure 2. Block diagram of observation protocol coding schemes for different types of formative assessment

Instructor Asks Student(s) Questions. The most complex type of formative assessment to code is questions that the instructor asks the students. Questions from the instructor may occur during lecture, or as a part of a larger active learning exercise such as a think-pair-share. The asking of a question is coded on three dimensions: 1) whether the instructor's **tone** in posing a question is inviting, neutral, or uninviting (included because the way in which a question is posed influences students' responses [5]), 2) the **cognitive orientation** of the instructor's question (e.g., whether it involves "task production," focusing on simply completing the assignment as directed, or "knowledge construction," focusing on deepening students' conceptual understanding [6], [7]). and 3) whether the **target** of the instructor's question is an individual student or the entire class. Students' responses to the instructor's question are also characterized by their **cognitive orientation** and the **instructor's response** is characterized as affirmative; neutral; corrective, directive (i.e. explicitly telling the student what is wrong); or corrective, facilitative (i.e. guiding the student to understanding what is wrong) [8].

Student Asks Instructor Questions. Previous work on this project [4] has contended that when students ask their instructor questions, the instructor can gain deeper understanding of how their students are thinking about the material and concepts. Thus, this can be an effective method of formative assessment. Student questions may be **invited by the instructor**, or students may ask a question without an explicit invitation. When the instructor invites questions, their **tone** may be inviting (e.g. "I need someone to ask a question before I move on."), neutral (e.g. "Any questions?"), or uninviting (e.g. "I know this is easy, but do you have any quick questions?"). The content of a student's question is coded based on its **cognitive orientation**, and the **instructor's response** is characterized as dismissive, a direct answer addressing task production, a direct answer addressing knowledge construction, the repetition of the question to the class, or the asking of a new question to the class [9].

Instructor Talks with Individual Student or Group. During active learning, the instructor has an opportunity to engage in formative assessment by walking around the classroom and discussing the problem with students. After these interactions occur, the researcher records whether or not the instructor addresses an aspect of this discussion to the entire class. For example, the instructor may answer a student's question for all to hear, or the instructor may repeat a student's problem-solving process to the class, validating it as a correct way of thinking. (Note, because the observer will not be privy to the actual conversation, they will have no information about the student response or the instructor response to those students.)

Instructor Implements Writing-Based Formative Assessment. Instructors may also implement writing-based methods of formative assessment in which students answer a prompt (e.g. "Write down the muddiest (most unclear) point from the past week.") [1]. Because of the nature of this type of assessment, students respond privately (and often anonymously) and the instructor analyzes and interprets students' responses out of class. As a result, these actions are not observable. However, the observation protocol asks the researcher to note when the instructor addresses information from these writing-based formative assessment methods in class. In order

to be coded as such, the instructor must make explicit reference to the writing-based assessment method.

Observer Field Notes

To provide context for these observations, researchers make field notes before and after each class concerning external factors that could potentially influence both student-instructor interaction and formative assessment. These factors include the general class mood, the time and day of the week, the proximity to exams, and positive or negative campus events. Observers also use field notes to further describe their selection of codes that are more subjective, such as the instructor's tone while inviting questions.

Next Steps

Development and refinement of the observation protocol continues with two main directions of work. First, instances of formative assessment are being coded in video recordings of ten different engineering science courses. First, one researcher will identify and transcribe instructor and student dialog during instances of formative assessment in three class meetings of each course. Then, multiple researchers will be trained to code each instance of formative assessment using the initial draft of the observation protocol. This procedure will serve multiple purposes: 1) to develop a procedure for training users of the observation protocol, 2) to further refine the coding scheme by identifying aspects of formative assessment that do not fit the initial draft of the observation protocol, and 3) to calculate inter-rater reliability, providing a quantitative measure of the validity of the coding scheme. In revising the observation protocol, additional existing theoretical frameworks will be identified that could help explain the currently uncoded aspects of formative assessment. Secondly, researchers will test the usability of the observation protocol in the field by using it in real-time to observe meetings of large-enrollment engineering science courses.

Once the observation protocol has been tested and refined, it will be used to characterize instances of formative assessment in multiple large-enrollment engineering science courses, allowing for quantitative and qualitative comparisons across these courses. These results will demonstrate ways in which instructors effectively implement formative assessment and change their teaching based on the feedback they receive, and they will also suggest ways in which formative assessment can be improved in traditionally lecture-based engineering science courses.

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