Automating the Measurement and Assessment of Classroom Discourse

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Abstract

Dialogic instruction, a style of classroom discourse, is a powerful predictor of student achievement in middle and high-school classrooms. In studies of dialogic instruction involving thousands of students across hundreds of classes, time spent on open discussions and the proportion of teacher authentic questions and questions with uptake were positive predictors on achievement. Unfortunately, the research is difficult to scale because dialogic instruction must be manually coded by trained observers. This project focuses on automatically analyzing classroom discourse using multimodal sensing, automatic speech recognition, natural language understanding, and machine learning. We developed an approach to record audio from classrooms to identify teacher versus student speech and automatically transcribe teacher speech. Ongoing research aims to autonomously code instructional activities (e.g., lecture, discussion), detect teacher questions, and analyze those questions with respect to authenticity and uptake. This approach provides quantifiable variables for teacher education, professional development, and classroom research and is generalizable, allowing other researchers to quantify additional variables of interest.

Overview

Dialogic instruction is a powerful predictor of student achievement:

- **Discussion**: Open exchange of ideas among at least three participants lasting longer than 30 seconds
- **Authentic teacher questions**: Open-ended questions without a pre-scripted answer rather than known-answer test questions
- **Uptake**: Speaker's incorporation of a previous answer into a subsequent question (e.g., "what did you mean by that")

This project focuses on automatic analysis of dialogic instruction

Teacher: *Is it Mr. Hollings' store? Is that it?*

Student: *No. Here's the reason. They don't get paid till the cotton comes in. But throughout the year they still have to buy stuff—food, clothes, seed, and stuff like that. So the owner of the plantation will sign for what they buy at the store so that throughout the year they can still buy stuff on credit.*

Teacher: *So, he has to have credit in order to buy things, and this store is the only one that will give it to him.*

Example dialogic exchange in a discussion session

Data Collection

- Teachers wore a headset microphone to capture high fidelity speech
- Classrooms were recorded with a pressure zone microphone
- Dialogic instruction was annotated by trained observers
- 77 sessions collected, totaling 780 hours, averaging 60±20 minutes each session, from 11 teachers, covering 1,600 instructional segments

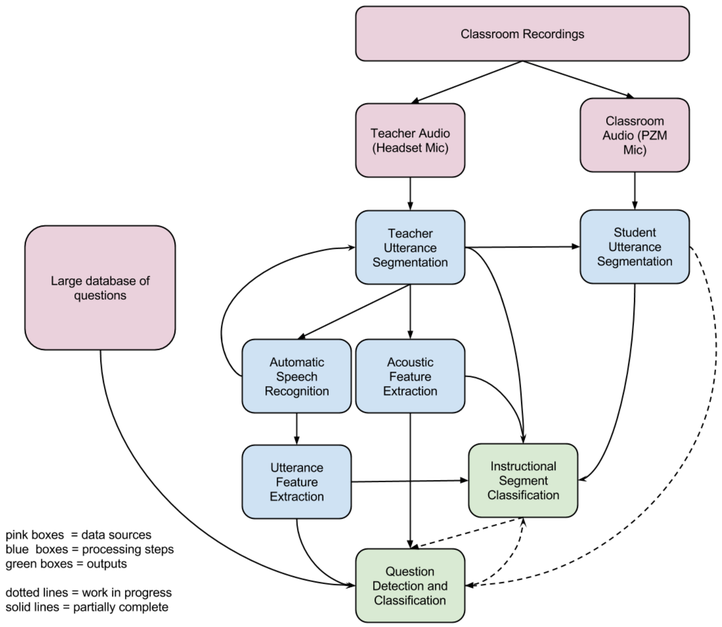


Teacher's microphone

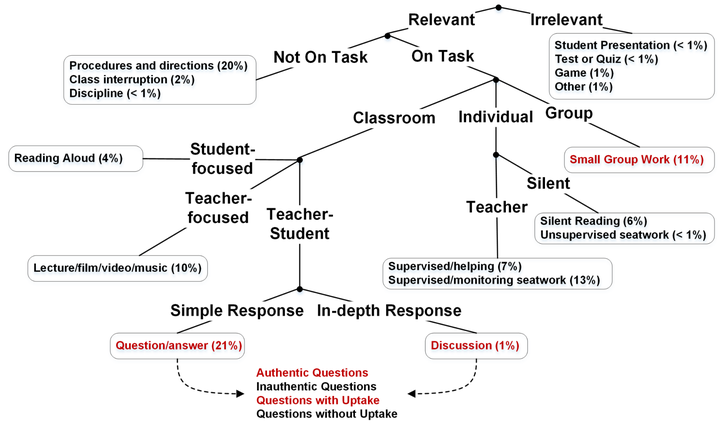


Classroom microphone

Technical Approach



Classroom Activities

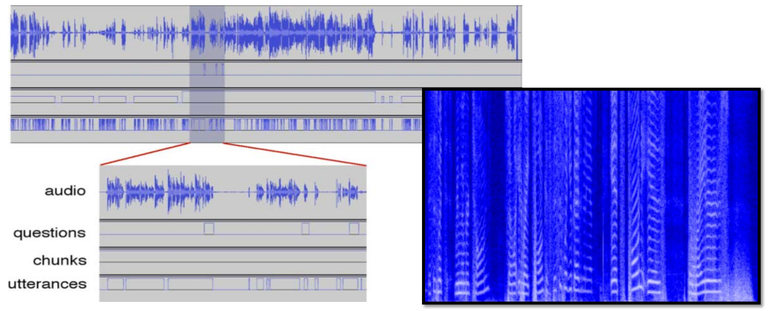


Hierarchy of instructional segments showing % of class time spent on each

*Components in **red** correlate with student achievement.*

Results (work in progress)

Classroom recordings are analyzed for temporal, acoustic, spectral, and natural language features.



(Left) Excerpt of classroom recording marked with utterances, dialogic questions, and instructional segments (Right) Spectrogram of a teacher's question

Machine learning models are trained to identify important components of dialogic instruction and are validated independently of the teacher.

Identification of teacher speech	$F_1 = 0.97$
Identification of student speech	$F_1 = 0.66$
Transcription of teacher speech	Accuracy = 69%
Identification of Q&A segments	$F_1 = 0.73$
Identification of individual questions	$F_1 = 0.56$

F_1 score is a measure balancing precision (relevance) and recall (specificity)

Next Steps

- Classification of question properties (authenticity and uptake)
- Assessing whether automatic coded dialogic instruction predicts student achievement similar to manual coding
- Dissemination of software/hardware to teachers, researchers, and professional development specialists

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