Teacher-Student Classroom Interactions: A Computational Approach

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ABSTRACT
Teacher-student interactions are key to most school-taught lessons. We present a new approach to studying these interactions; this approach is based on a fine-grained data collection, using quantitative field observations (QFOs), which relies on a well-established theoretical framework. The data collected can be analyzed in various methods to address different types of research questions; we give some examples to demonstrate this potential.

Keywords
Teacher-student interactions, quantitative field observations, different analysis approaches.

1. INTRODUCTION
Since the early days of Plato, over 2,300 years ago, dialogues were at the heart of the teaching practice. For as long as classroom teaching exists, teacher-student interactions have been the key to most school-taught lessons, hence studying these interactions is decades-old. Many studies in this field that have used classroom observations, often manually documented each occurrence of a teacher-student interaction, usually by observing a small cohort of students at a time or by observing individual students based on an interval-based protocol (e.g., Good & Brophy, 1970; Cameron, Cook & Tankersley, 2012; Luckner & Pianta, 2011). We use a digital data collection tool—a tablet app developed specifically for this purpose—in order to conduct quantitative field observations (QFOs). Although documenting each occurrence of a teacher-student interaction, data is not collected at the student-level (i.e., students are not labeled, only interactions), which makes it feasible to have a single person observing a whole class and still document every interaction during it. Once the class is over, the data is ready to be analyzed. More than that, this fine-grained data is time-stamped, which allows for advanced, including temporal, analyses.

2. THEORETICAL FRAMEWORK
Good and Brophy's (1970) method, developed in the context of mathematics education, was probably the first to refer to a single student—as opposed to the whole class—while recording public classroom interactions, hence focusing on dyadic teacher-student interactions**. T**his protocol was later modified by Reyes and Fennema (1981), who considered non-public teacher-student interactions too.

These validated protocols have been in use to study various variables at different grade levels and in many learning settings. Due to their validity, fine granularity and popularity, we find these protocols very suitable for our research. Adapting and extending the original protocols to better fit to our research setting—mainly to the whole class being observed at all times—we categorize each teacher-student interaction to one of the categories described in the next sub-sections.

2.1 Response Opportunity
A response opportunity is a public attempt by an individual student or a group of students to deal with a question posed by the teacher. Interactions that fall under this category take one of four possible values: **Direct** – the teacher asks a direct question of an individual student; **Volunteer** – the teacher asks a question, waits for the students to raise their hands, then calls on one of the children who has his hand up; **Call Out Single** – the teacher asks a question and a student calls out an answer without waiting for permission to respond; **Call Out 2+** – the teacher asks a question and more than one student call out an answer without waiting for permission to respond.

2.2 Immediate Contact
An immediate interaction is a public, content-related interaction initiated by the teacher, a student or a group of students that is not preceded by a teacher's question. This category again has four values based on the interaction initiator and the number of students involved in it: **Teacher to Single**, **Teacher to 2+**, **Single to Teacher**, **2+ to Teacher**.

2.3 Behavioral Contact
These are public, behavior-related comments of the teacher. Here too, four values are defined, based on the type of behavior commented and on the targeted audience: **Discipline to Single**, **Discipline to 2+**, **Appraisal to Single**, **Appraisal to 2+**.

2.4 Procedural Contacts
These interactions are public, non-content related; they are related to students' management or to the class management, e.g., permission, supplies, or equipment. Like *Immediate*, we distinguish the interaction initiator and the number of students involved, hence its four values are: **Teacher to Single**, **Teacher to 2+**, **Single to Teacher**, **2+ to Teacher**.

2.5 Non-Public Interactions
Non-public interactions are held privately between the teacher and one or more students. As such, we assume not being able to categorize them, therefore we only code whether they were **Teacher-Afforded** or **Student-Initiated**.

3. DATA COLLECTION APP
As mentioned above, a dedicated data collection app was developed for the purpose of this study. The app, Q-TSI

(Quantifying Teacher-Student Interactions), is available for free via Google Play Store[1]. Besides coding the interaction categories, the app allows documenting the following contextual variables:

- **Learning Configuration** (whole class discussion, group work, pair work, individual work);
- **Technologies in Use by the Teacher** (blackboard, projector, smart board, book – any combination of these are allowed);
- **Technologies in Use by the Students** (book, computer, book and computer);
- **Teacher Location** –on a 4x4 division of the classroom.

Furthermore, the app allows the user to enter any (time-stamped) comment s/he finds useful. These comments might be useful to interpret the results of analyses. The data is stored locally on the observer device as a CSV file.

4. ANALYSES APPROACHES

The collected data can be analyzed in various ways in order to address a wide range of research questions. We now describe a few potential research directions we are currently considering (some will be demonstrated in the poster).

4.1 Visualization

Visualization can be a powerful tool to have an overall understanding of the classroom dynamics. Teachers can gain awareness and reflect upon their interactions with their students during the class. A typical visualization may include a time-ordered representation of the interactions, differentiated by type (e.g., by color, marker), along with values of the contextual variables. Such visualizations may assist in initially having an overview of the kinds of interactions that happen, exploring differences within classes, based on, e.g., learning configuration or technologies in use, or between classes, based on, e.g., teacher, school, grade-level, subject matter, time of day, etc.

4.2 Statistics

Basic statistics may shed light on the overall distribution of the different types of interactions in a lesson, as well as on differences within and between classes (based on variables as such as were mentioned in *4.1 Visualization*).

4.3 Time-based Patterns

Association rules, time series, statistical discourse analysis and epistemic network analysis may assist in understanding whether there are specific interactions that often occur jointly or in connection, possibly, in some specific order or in a specific context, and how occurrences of interactions evolve over time. Time in our context has at least two levels of granularity: the lesson granularity (i.e., what happens during one lesson) and the school year granularity (i.e., what happens in lessons over the weeks).

4.4 Cluster Analysis

Clustering techniques can be used to explore whether classes can be classified according to typical patterns of interactions. Several ways of describing a lesson and, consequently, of comparing lessons, can be investigated. For instance, a mere quantitative analysis can be used to characterize a lesson, that is, counting interactions and using the Euclidean distance (or alike) for clustering. A lesson can also be described as a sequence of different interactions over time, then using the Levenshtein distance (or alike) for clustering. It might be necessary to define several abstraction levels for the interactions.

4.5 Prediction

It might be possible to predict different types of interactions based on historical data, or based on contextual variables. A possible prediction might look like: "three <Response opportunity: Call out 2+> interactions and two <Procedural: Teacher to single> interactions are followed by a <Discipline: Single> interaction in 85% of the instances." Several techniques will be considered to investigate this kind of patterns, in particular, classification techniques enriched with time series and statistical discourse analysis.

4.6 Collecting More Data

In the future, additional data will be collected, such as students' log files, performance, meta-cognitive and affective measures, in order to enrich the data with more layers. These layers will allow, in turn, to ask even more questions about the data and to better investigate the role of teacher-student interactions in the learning/teaching process.

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6. REFERENCES

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