

Using hierarchical logistic regression analysis to investigate equity in classroom discourse

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Abstract: This paper presents a novel methodology for examining equity in classroom discourse. Coding discourse data at the level of the exchange (rather than the utterance) affords investigation of the relationships between teachers' expectations, teaching patterns, students' social backgrounds and participation patterns. Using a hierarchical logistic regression model, we found that the likelihood of students' answers being developed by the teacher in this particular classroom was greater for Jewish students, for boys, for students from higher socio-economic backgrounds, for answers given following teacher nomination, and for relevant responses. In contrast to previous studies, the teacher's perception of the student's learning ability and the type of question posed had no statistically significant effect on the likelihood of the teacher developing the student's answer. The study contributes to our understanding of the mechanisms of educational injustice, to the development of methods for investigating equity in classroom discourse, and – thereby – to its rectification.

Theoretical framework: Participation and equity in classroom discourse

Studies of classroom interaction drawing on sociocultural theory (Vygotsky, 1978) stress students' active participation as a necessary component for fostering learning opportunities and outcomes (e.g. Snell & Lefstein, 2018; Black, 2004; Howe, Hennessy, Mercer, Vrikki, & Wheatley, 2019; O'Connor, Michaels, & Chapin, 2015). Applying this lens, other studies showed there are differences in students' participation in terms of frequency and quality, based on socio-economic background (Black, 2004), ethnicity (Kelly, 2008), and gender (Myhill, 2002). Differences in student participation could be the result of personal qualities, such as cognitive abilities, intrinsic motivation, attitudes towards school, etc. (Jurik, Gröschner, & Seidel, 2014).

A complementary perspective sees variations in participation levels as caused by the teachers' differential behavior towards students from different backgrounds (Sedova & Salamounova, 2016). Thus, teachers' expectations from their students likely affect the ways in which they interact with their students and influence how and what they teach, which may in turn shape students' learning processes and outcomes (Wang, Rubie-Davies & Meissel, 2018). Such differentiated teaching likely has negative consequences, especially when based upon students' social background, perceived ability and/or prior achievement (Black, 2004; Kelly, 2008). Teachers' implicit biases have been shown to influence their expectations of their students (Adair, Colegrove & McManus, 2017), leading to differential treatment and differential learning opportunities (Black, 2004; Snell & Lefstein, 2018). The above-quoted studies focused on teacher actions. However, Calarco (2018) argued that children are not the passive victims or beneficiaries of teachers' biases. Studies of teachers' expectations cannot, in most cases, explain whether teachers' responses are shaped by students' behaviors or by their demographics, because they rarely discuss how students' behaviors may shape differentiated teaching (Calarco, 2018). A few qualitative studies have combined teachers' expectations and behavior with student behaviors, but focused on case studies of individual students, which are telling but unsystematic (Black 2004; Orner & Netz, 2021; Snell & Lefstein, 2018; Sedova & Salamounova, 2016). Similarly, Wang, Rubie-Davis and Meissel's (2018) recent systematic review of quantitative studies on teacher expectations suggests that studies of students' classroom behaviors as both an outcome and a mediating factor of the effects of teachers' expectations have received limited scholarly attention. Only four quantitative studies of this question were identified during the past decades, with inconsistent findings. Based on their review they argue that it is necessary to examine quantitative variables (e.g., how often and for how long students speak) alongside qualitative variables (e.g., utterances' content, immediate context, and identity work).

One problem limiting current efforts to bridge the gap described is the lack of a suitable methodology. Addressing this methodological gap, the present study proposes a new methodology for examining equity in classroom discourse. This methodology involves expanding the unit of analysis from the utterance to the exchange, which enables examination of the inter-relationships between multiple identity categories (e.g., gender, nationality, socio-economic status, the teacher's perception of the student's abilities) and discourse forms (means of attaining the floor, type of question addressed, relevance of the response). Such expansion of the unit of analysis allows us to use hierarchical logistic regression analysis to address complex issues such as: Does the teacher

develop (through elaboration moves) more answers from boys because they are viewed as more capable or because they tend to answer open questions and their answers are viewed as more relevant?

To understand such gender differences, a model that controls the various variables is required. Understanding the fine-grained workings of this and similar mechanisms is a crucial step towards their rectification. To illustrate the methodology, we address the following research question: How do background characteristics, perceived learning ability and patterns of students' participation affect the likelihood of the teacher developing students' answers? Teacher development of student answers is critical to learning processes because it takes students' ideas seriously, either by challenging them or building on them. Examples of teacher development include probing the student to elaborate their (usually, his) response, or posing an uptake question: that is, a new initiation that incorporates the student's answer. Previous studies have found these questions to be "optimal patterns" that increase participation and thus increase learning opportunities (e.g., Howe et al., 2019).

According to the research hypothesis, the likelihood of developing an answer will be higher among boys, Jews, students from high socio-economic status, with high perceived abilities who answer open-ended questions, receive permission to speak with the teacher's approval, and provide relevant answers. We hypothesize that patterns of students' participation (means of attaining the floor, relevance of the response) and perceived learning ability will shape the likelihood of teachers' developing student responses. Moreover, we hypothesize that these variables will not be sufficient to explain the correlation between student background variables (gender, nationality, socio-economic status) and the likelihood of teachers' developing student responses. Rather, we expect that demographic variables will have an impact above and beyond student behavior.

Research setting

This illustrative case study is part of a design-based research project conducted in 21 Israeli Hebrew-speaking secular state schools and designed to promote academically productive talk. One of the issues we investigated, in a focused study in a sub-set of two schools, is how students' social backgrounds shape their educational experiences and learning. The current study was conducted in one of the schools participating in these two projects. The class was composed of 24 fifth graders, aged 10-11: 15 boys and 9 girls, from middle to low socioeconomic backgrounds, and their language arts teacher. Four of the students were Arab, which was out of the ordinary in the relatively segregated Israeli education system, in which students from each sector (secular Jewish, religious Jewish, ultra-orthodox Jewish, Arab and Druze) study separate curricula in separate schools. We chose to focus on this classroom due to the diverse backgrounds of the students who study in it. The data were collected during the 2019-2020 school year. All participants and their parents or guardians gave informed consent.

Data collection and analysis

Data analysis is based on a subsample of eight lessons that were observed, videotaped and transcribed in full. The transcripts were arranged in a database ([Figure 1](#)), with each line representing an event, which we defined as a sequence that opens with the teacher's initiation, proceeds to a student response and concludes with teacher feedback (adapted from IRE – Initiation, Response, Evaluation (Mehan, 1979)). The arrangement of events requires the exercise of judgement that may affect the findings – for example, when the teacher's request leads to several overlapping responses and one feedback that is difficult to characterize for whom it is intended. In this case, one researcher segmented all the events. After segmenting the data set, we coded each event (N=1142) according to categories developed and adapted from previous studies of class discourse ([Table 1](#)). Although we coded other variables, we only report here the variables included in the regression. We used Cohen's *kappa* test to calculate inter-rater reliability of the coding. We estimated a hierarchical logistic regression model to predict the likelihood that the teacher would develop the student's response given background characteristics, perceived learning ability, question type, the form of the student's bid for participation and the relevance of the response.

Findings

Variables shaping the likelihood of a student's answer being developed by the teacher

Our macro unit is the students, within which are nested interactional events (micro-level). Because we are interested in the differences between students as well as the differences within each student from interaction to interaction we chose the random slope model where each student has his/her own slope. Table 2 summarizes the coefficients and standard errors of the hierarchical logistic regression model predicting the likelihood of the student's answer being developed by the teacher.

Table 2

Hierarchical logistic regression model predicting the likelihood of a student's answer being developed by the teacher (N=1142)

	Exp (B)	SE
ISEI	1.043***	0.012
Gender (ref: Boys)	0.223***	0.076
Nationality (ref: Arab)	4.664**	2.356
Perceived learning ability	1.044	0.104
Teacher's question (ref: Closed)		
Open question	0.992	0.182
No question	0.527*	0.153
Speaking with permission (ref: without the teacher's approval)	3.226***	0.539
Relevance of the answer (ref: Irrelevant)		
Non an answer to a question	0.729	0.272
Relevant	2.062*	0.606
N^2	1142	

* $p < .05$ ** $p < .01$ *** $p < .001$

The findings of this study present a complex picture in relation to the effect of background characteristics, perceived learning ability, and students' participation on the likelihood of this teacher developing their answers. On the basis of previous studies we expected to find statistically significant effects for gender, nationality and socio-economic status on the likelihood of the teacher developing students' answers. Indeed, the likelihood of developing a girl's answer was 78% lower on average compared to boys while controlling the other variables; each increase of a unit in socio-economic status increases the likelihood of the answer being developed by 1.04 points on average while controlling the other variables; and the likelihood of Jewish students' answers being developed is 4.6 times greater on average compared to Arab students while controlling the other variables. However, in contrast to previous studies, we were surprised to find that the regression model of the learning ability perceived by the teacher has no statistically significant effect on the likelihood of the answer being developed by the teacher. This can probably be explained by the relationship of the ability variable with the additional background variables – a relationship that requires further examination in a broader sample. Regarding the question characteristics, the findings also contradicted the research hypothesis that the likelihood of developing answers to open-ended questions would be higher. In fact, the effect of the type of question (open/closed) was not statistically significant. This surprising finding requires qualitative examination beyond the scope of this work. Moreover, the likelihood of a student contribution that was offered not in response to a question being developed is 47% lower on average compared to an answer to a closed question while controlling the other variables. In accordance with our hypothesis, the probability of answers given with the teacher's approval to be developed is 3.2 times higher on average compared to answers given without explicit permission while controlling the other variables. In addition, the likelihood of a relevant answer to be developed is 2.06 points greater on average compared to irrelevant answers while controlling the other variables. Finally, the variance of the random slope, i.e. the variance between each student's mean value of responses being developed is almost zero (4.19e-33). Also, the fact that there is not necessarily a need for a random slope, that is, that the dependence between the observations for each student is not high, contradicted our hypotheses.

Limitations

Although the model findings are not the focus we will note that there are limitations to the sample which limit the validity of the findings. First, the analysis is based on observations of eight lessons in only one classroom that deviates from the normal distribution. In order for the chosen model to be valid it is necessary to expand the sample so that it meets the normality assumption. Second, the homoscedasticity assumption, according to which the variance in each of the random components is the same throughout different values of the explanatory variables, does not appear to hold for the following variables: gender, nationality, socio-economic status, perceived academic ability. However, the assumption does hold, i.e. the variance is fixed, for the different modes of the teacher's question, the manner of obtaining permission to speak and the relevance of the answer. Another limitation is that this study of one teacher in one classroom is in no way representative of other teachers and other classrooms. We build here on Shaffer and Serlin's (2004) use of intra-sample statistical analysis as a technique for using quantitative tools to support qualitative inquiry. As such, our findings "don't 'generalize' in the

traditional quantitative sense, but they do justify drawing statistically based conclusions about observations in a qualitative context” (p.3).

Regarding the methodology, the arrangement of events according to the IRE structure imposes upon the discourse a teacher-led structure that may not always be appropriate and obscures, for example, interaction between students that is not mediated by the teacher (though this was not a problem vis-à-vis the current data set). In addition, the model does not take into account the cases of silent students, who did not participate at all. Similarly, we included in the analysis only events in which students actually spoke. A more complete picture would include students who bid for turn but who were not nominated and did not speak without permission. We intend to address these limitations in future research.

Significance of the study

Expanding the unit of analysis from the utterance to the exchange in the methodology we developed helps bridge the gap in the literature in relation to the mediation process between teachers' expectations and perceptions of learning ability, teaching patterns and students' participation patterns. In this case we presented a model that predicts teacher elaboration moves on the basis of student background variables and participation, but many other predictive models can be constructed, for example, for predicting students' participation patterns based on background characteristics and teaching patterns. Exposing these patterns and power relations enhances our understanding of existing mechanisms in classroom discourse that promote or hinder learning opportunities, advancing us towards their rectification, and its conclusions may be used in designing a teaching strategy that promotes equitable participation among learners. As noted above, the contribution of this paper is methodological; realizing the potential of this methodology requires using it in examination of a broader, ideally representative sample.

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