

## Pedagogical Communication Language in Video Lectures: Empirical Findings from Algebra Nation

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**Abstract:** Online tutoring has become a primary instructional delivery method with increased global health restrictions. Providing effective communication strategies is critical in video lectures to reduce the physical gap between the tutors and learners for effective learning. Hence, this study presents empirical findings regarding the communication strategies of algebra tutors in online video lectures. We used two advanced psycholinguistic tools, Coh-Metrix and SÉANCE, to investigate how the algebra tutors explored different language choices with specific sentimental values. In addition, the different teacher-talk strategies were identified within levels of their pedagogical discourse marker use. The results revealed the importance of linguistic and sentimental indices to understand the communication strategies of the tutors providing instruction on various algebra topics. The findings further suggested that tutors tend to focus on providing intentional language cues in the form of pedagogical discourse markers to help build rapport with the learners in an online learning environment.

**Keywords:** Online Education, Algebra Tutoring, Pedagogical Communication, Theory-based Natural Language Processing, NLP

### Introduction

The recent and sudden increase in demand for distance learning has raised interesting, but daunting questions for educators concerning delivery and evaluation methodologies in the realm of virtual learning. With highly restrictive regulations on in-person activities, a dramatic decrease of in-person exposure in all education activities is expected, including instructional activities. To provide an immediate solution to such problems, a large proportion of public and private education has moved to online modality. The instructions are provided using alternative interaction platforms, such as online tutoring and video lectures (Chick et al., 2020). Video lectures are one of the most widely used education strategies (Allen et al., 2002; Buckley & Smith, 2007; Choi & Johnson, 2005). Video lectures enable a boundless learning experience by allowing students to access the learning resources efficiently. Students can access and revisit the video lectures when needed, thus allowing students to learn at their own pace (Whatley & Ahmad, 2007; Brecht & Ogilby, 2008). Moreover, video lectures provide increased options for students to select the design, resources, and instructional styles based on their learning types (Lange & Costley, 2020).

In order to provide effective video lectures with such benefits, it is integral to ensure that the lecture content is delivered with clear and effective communication strategies (Costley et al., 2020). Effective communication is particularly important in video lectures to overcome the lack of human interaction in distance learning. Students commonly report feeling isolated in the distance learning environment as one of the biggest factors impacting their learning interest and motivation (Lee & Rha, 2009). Moreover, the lack of immediate feedback from the instructor paired with unclear instructions may induce confusion and frustration among students (Mayer, 2005). However, despite the concerns, there has been limited empirical research that understands and evaluates the effective frameworks of communication in video lectures (Breslow et al., 2013). In video lectures, educators are expected to communicate with the students using highly sophisticated teacher-talk strategies to facilitate more supportive and interactive environments to motivate the learners (Lee, 2010; Atapattu & Falkner, 2017). For instance, previous studies indicate that the tutor's intentional use of language to build social interaction with the students is integral to encourage effective student engagement and learning (Brame, 2016; Guo et al., 2014; Richardson & Swan, 2003).

However, while broad guidelines and suggestions have been presented by previous studies, there is still lack of empirical evidence to provide an in-depth understanding regarding how such teacher-talk strategies appear in various domains of online learning video lectures, such as algebra learning. Hence, the purpose of this study is to address this gap in the literature by analyzing the communication components in tutoring videos by investigating the tutor's communication component in lecture videos in terms of their psycholinguistic and pedagogical discourse characteristics.

To this end, we used psycholinguistic tools and natural language processing (NLP) augmented by theory-based discourse analysis. Our objective is to discover how intentional language choice in teacher-talk occurs in algebra video lectures, using the findings from the empirical dataset. As a result, this study focuses on understanding and evaluating how such teacher-talk strategies are used in online learning environments, in particular for Algebra Nation (Lastinger Center for Learning & University of Florida, 2019), an interactive algebra learning platform for grades 6-8 that includes video tutoring lectures. The following two research questions were addressed to guide the study: (1) Do tutors in Algebra Nation use different language strategies to establish better communication? If yes, what types of linguistic differences and strategies the tutors use to establish better communication in an online learning environment? (2) What types pedagogical discourse markers do tutors use to establish better communication?

## Literature Review and theoretical background

### Importance of Effective Communication in Video Lectures

Effective communication in video lectures reduces the physical gap between the instructor and students and overcomes the challenges that arise due to the lack of human interaction in distance learning (Lee, 2010; Atapattu & Falkner, 2017). Previous studies have emphasized the importance of instructors' communication strategies for enhancing effective learning in video lectures (Richardson & Swan, 2003; Guo et al., 2014; Brame, 2016). For instance, Richardson and Swan (2003) indicated that the communication style of the instructors in video lectures could have a significant impact on students' cognitive performance and their satisfaction. Similarly, Guo et al. (2014) suggested that the tutors' speaking style in the video lecturers is one of the important factors that impacts the effectiveness of video lectures. The empirical study focused on analyzing 6.9 million video watching sessions from courses on the edX MOOC platform to understand the effect of various factors on student engagement and learning outcomes. The findings suggested that students could engage better with talking-head videos. Students identified that talking-head videos are more "intimate and personal", thus, positively impacting their engagement. Also, students could engage more with video lectures when the instructor spoke faster. The study provided important insights to investigate the communication style of the instructor to increase lecture effectiveness. However, the suggestions were relatively limited to diagnostic recommendations regarding a tutor's language use for ideal communication styles in video lectures.

### Pedagogical discourse marker framework

The role of strategic teacher-talk using discourse markers has long been emphasized in traditional classroom learning (Consolo, 2000; Morell, 2007). Fung and Carter (2007) introduced a comprehensive framework, which categorizes commonly used pedagogical discourse markers into four functional levels (Table 1). The comprehensive pedagogical discourse framework was designed to provide systematic structures of evaluation of such intentional instructional cues. The framework categorizes commonly used pedagogical discourse markers into four different functional levels: Interpersonal, Referential, Structural, and Cognitive. Each function focuses on providing a pleasant student learning experience by a) reducing social distance between a teacher and a student [interpersonal], b) providing grammatical connectives to the sentences [referential], c) signaling topic shift [structural], and d) denoting thinking processes [cognitive]. In the current study, we adopted the Interpersonal, Structural, and Cognitive categories to provide a customized evaluation and analytic framework of the tutors' communication strategies in the video lectures. The referential category was not adopted in the analysis as the category introduced discourse markers of low interest based on the primary research questions of the current study. In short, the functional paradigm of pedagogical discourse marker frameworks (Fung & Carter, 2007) was adopted to enhance the interpretability of the empirical findings from the natural language processing analyses.

Table 1: Functional Paradigm of Pedagogical Discourse Marker Framework (Fung & Carter, 2007)

Interpersonal Function	Structural Function	Cognitive Function
- Marking shared knowledge (e.g., <i>see, you see</i> )	- Opening and closing of topics (e.g., <i>let's start</i> )	- Denoting thinking processes (e.g., <i>well, I think, I see</i> )
- Indicating attitudes (e.g., <i>well, I think</i> )	- Sequence (e.g., <i>first, second, next</i> )	- Reformulation & self-correction (e.g., <i>I mean</i> )
- Showing responses	- Topic shifts (e.g., <i>how about</i> )	- Elaboration (e.g., <i>for example</i> )
	- Summarizing opinions (e.g., <i>so</i> )	- Hesitation (e.g., <i>well, sort of</i> )
		- Assessing learner's knowledge

(e.g., <i>okay, yeah, great, I see</i> )	- Continuation of topics (e.g., <i>yeah, so</i> )	(e.g., <i>you know</i> )
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## Methods

### Data

We analyzed 125 video lectures by five tutors collected from Algebra Nation. Algebra Nation is an online learning platform, which provides free learning resources to students and teachers. The learning contents in Algebra Nation follow the core standards for Algebra 1 in the designated state to provide effective algebra learning modules, such as online practice tools, interactive wall post, and dynamic video lectures. In the current study, we analyzed the video lectures, which included 25 topics from three main algebraic concepts introduced by each instructor. The lectures spanned between 10.7 and 22.0 minutes ( $M=17.2$ ;  $SD=5.0$ ). The video content was designed to follow the same algebra workbook content. The workbook content introduced algebraic concepts and practice questions to help improve student learning<sup>1</sup>. Given that the videos covered the same workbook content, we hypothesized that the differences in the videos' length stemmed from the varying problem-solving and communication strategies used by the tutors. As such, we focused on analyzing the communication strategies geared towards engaging and motivating students, referred to as the “communication” component in the following sections.

### Analysis Framework

The analysis was conducted in three stages to investigate how teacher-talk strategies were employed in video lectures from Algebra Nation. In the first stage, the video lecture transcripts were parsed into three categories based on their content. This was to identify and extract the “communication” component from the video transcripts, which served as the primary focus of the current analysis. The other two categories included the “workbook” and “lecture” components. These components referred to the parts of the text where the tutor rephrases the workbook content and explains algebraic concepts or solutions. The second stage of the analysis focused on understanding the differences in language use in the communication component among the tutors using the psycholinguistic features. We extracted an extensive list of psycholinguistic indices from the communication content of the video lecture transcripts using Coh-Metrix (McNamara et al, 2014) and SÉANCE (Crossley et al., 2017). Then, we used the Random Forest classifier to investigate whether the psycholinguistic features could accurately classify the tutors. The feature importance indices were inspected to understand the relative contribution of the variables to the classification outcome. In stage 3, we focused on understanding the differences in the tutor's language by identifying and comparing pedagogical discourse markers. This was achieved by extracting discourse markers using n-gram-based clustering. We then identified the discourse markers patterns used by each tutor. The findings from the last two stages of the analysis are described and explored thoroughly in the Results section.

## Results

### Differences in the Language Use and Sentimental Component

A total of twenty-six features were identified to provide deterministic information to classify the algebra tutors based on their communication language use (Random Forest (RF) Classifier, accuracy on the test set=86.7%). The final feature set included fourteen sentiment component scores from SÉANCE and twelve Coh-Metrix indices. Tables 2 and 3 and Figure 1 provide detailed descriptions of the SÉANCE and Coh-Metrix indices included in the final model. More specifically, four specific categories of Coh-Metrix indices were located to have high classification power. The four categories included, “Word Information”, “Text Easability”, “Syntactic Pattern Density”, and “Situation Model”. The word information index (WRDPRP1p, “First-person plural pronoun incidence”) shows the highest contribution (8.9%) to accurately classify the communication components in video scripts based on tutors. This suggests the frequency of tutors using words, such as “we” and “us” could work as a good indicator for differentiating communication components among the tutors. Also, the polysemy for content words (2.6%) and verb incidence scores (4.3%) were identified as deterministic variables from the word information category. Polysemy for content words identifies the average number of distinct meanings the word represented. Hence, it is often highly related to the ambiguity of text due to the larger room for varying interpretations. This suggests the varying level of ambiguity of the communication component could help differentiate the teacher-talk among the algebra tutors. Similarly, the tutors' communication components could be differentiated using their text easability measured by narrativity (3.7%), verb cohesion (3.4%), syntactic simplicity (3.2%), and connectivity (2.6%). This suggests the varying level of difficulty, or easability, of the communication

of the tutors as an important indicator to differentiate their teacher-talk strategies. In terms of the syntactic pattern density features, the noun phrase density score (4.6%), expanded temporal connectives incidence score (3.7%), and the preposition phrase density score (3.5%) were identified as deterministic features. Lastly, one feature was identified as significant in the situation model category. This category of features represents the level of mental representation of the readers based on the content provided in the text. Specifically, the intentional content features (3.7%) attempt to understand the “intentional actions, events, and particles” provided in the text (McNamara et al., 2014, p.66). Hence, our findings indicate that the tutors' use of intentional language in the communication content significantly identifies the varying teacher-talk strategies among the algebra tutors (Figure 1, Table 2).

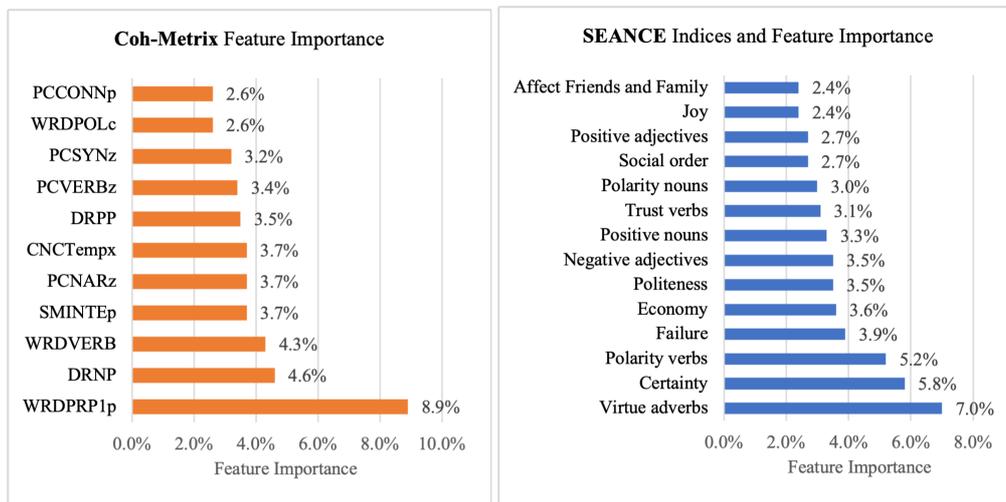


Figure 1. Final Random Forest classifier feature importance of the top 25 Coh-Metrix and SÉANCE features

Table 2: Final Random Forest Feature Importance of Coh-Metrix Indices

Category	Index	Description	Importance (%)	Total (%)
Situation Model	SMINTEp	Intentional content	3.7%	3.7%
Syntactic Pattern Density	DRPP	Preposition phrase density	3.5%	11.8%
	NCTempx	Expanded temporal connectives incidence	3.7%	
	DRNP	Noun phrase density	4.6%	
Text Easability	PCCONNp	Connectivity	2.6%	12.9%
	PCSYNz	Syntactic simplicity	3.2%	
	PCVERBz	Verb cohesion z score	3.4%	
	PCNARz	Narrativity	3.7%	
Word Information	WRDPOLc	Polysemy for content words	2.6%	15.8%
	WRDVERB	Verb incidence	4.3%	
	WRDPRP1p	First person plural pronoun incidence	8.9%	

The SÉANCE indices thus identified how the varying language choices conveyed different sentimental values in the algebra tutor’s communication component. The final 14 indices from SÉANCE included various component scores regarding virtue adverbs, certainty, polarity verbs, failure, economy, politeness, negative adjectives, positive nouns, trust verbs, polarity nouns, social order, positive adjectives, joy, and affect friend and family. Table 3 provides detailed information on the description and the importance of each component score with example words. Given the current dataset contains the communication component of algebra video lectures, the findings provide important insights regarding the types of words tutors differentially select to communicate with the students differently. More specifically, the use of adverbs related to virtue (7%), certainty (5.8%), and failure (3.9%) showed relatively high contributions to the classification outcomes. To summarize, the random forest feature importance outcomes with psycholinguistic features from Coh-Metrix and SÉANCE indicated the varying word selection in communication components among the tutors. The findings suggest that the intentional choice of words, measured by the word information, the syntactic structure, and the text easability indices, varied

significantly among the tutors. Also, the various sentiment behind the word choices were identified as an important factor differentiating the communication components of the five algebra tutors.

Table 3: Final Random Forest Feature Importance of SÉANCE Component Scores

Component	Description & Importance	
Virtue adverbs	Nouns related to worship and forgiveness (e.g., <i>blame, conviction, earn</i> )	7%
Certainty	Words indicating “a feeling of sureness, certainty, and firmness” (e.g., <i>absolute</i> )	5.8%
Failure	Verbs indicating power decreasing (e.g., <i>attack, banish, beat</i> )	3.9%
Economy	Words related to economy (e.g., <i>account, affluence, agricultural</i> )	3.6%
Politeness	Words concerned with a tools or forms of invoking formal power (e.g., <i>civil</i> )	3.5%
Negative adjectives	Negative adjectives (e.g., <i>abject, abrasive, abominable</i> )	3.5%
Positive nouns	Positive nouns (e.g., <i>acceptance, abundance, accomplishment</i> )	3.3%
Trust verbs	Words describing the state of trust (e.g., <i>admire, adore, anticipate</i> )	3.1%
Social order	Words concerning social order (e.g., <i>adhere, appall, corrupt</i> )	2.7%
Positive adjectives	Positive adjectives (e.g., <i>absorbent, able, accessible</i> )	2.7%
Joy	Words related to joy (e.g., <i>superb, affection, complement</i> )	2.4%
Affect Friends and Family	Nouns related to friends and family (e.g., <i>brother, company, friend</i> )	2.4%

### Pedagogical Discourse Marker Identification

We next identified how such differences in word use or language use in communication components occur differently for each tutor using pedagogical discourse marker clustering analysis. Unlike the previous analysis, the findings from the pedagogical clustering analysis can potentially reveal the explicit differences in pedagogical language use among the tutors. Seventeen pedagogical discourse marker clusters were identified using K-means clustering analysis of 6,119 sentences belonging to the “communication” components. The final model used tf-idf vectorization with n-grams ranging from 1 to 5. The k-means clustering results identified a number of interpretable discourse marker cluster categories. However, we also noted a non-negligible proportion of samples indicating relatively unclear results (18.9%). This could be largely due to the noisy structure of the text data.

While the results located interpretable groups of pedagogical discourse markers, it was necessary to provide theoretical support to decipher their core functional roles in teacher communication. As a result, the final set of discourse marker clusters was evaluated using Fung and Carter’s (2007) framework. Table 4 provides the final discourse marker identification results that are organized based on the discourse marker function framework. This framework identifies the core functional category of pedagogical discourse markers using the primary functions, such as the “interpersonal”, “structural”, and “cognitive” functions (Fung & Carter, 2007). A mapping was found for each cluster by locating the best-fitting category based on the pedagogical function. The resulting categories consisted of seven specific discourse function categories.

Table 4: K-means Clustering Results based on the Pedagogical Discourse Markers by Fung & Carter’s (2007)

Core Functional Category		Discourse markers	Cases (N)
Interpersonal Function	Marking shared knowledge	<i>we are close; we are almost there</i>	45
		<i>we know that; we know what to do; we have this to solve</i>	145
		<i>That is what is happening; that is what is up; that is how we do</i>	188
	Indicating Attitudes	<i>This is very important; you should be careful; this is a bit tricky.</i>	98
	Showing Responses	<i>That is good; that looks good; awesome job</i>	312
		<i>Ok, that is cool; cool; alright; all right; fantastic</i>	1,459
		<i>That is true; that is incorrect; yes; no</i>	386
<i>There you go; here you go; just like that; there it is.</i>		190	
Structural Function	Opening and closing of topics	<i>you got this; you guys are smart; keep studying hard</i>	178
		<i>Hi everyone; hey Algebra Nation</i>	128
	Topic Shifts	<i>Thank you; I will see you next time; see you in the next video.</i>	140
<i>Let’s see; let’s take a look; let’s jump in</i>		855	
Cognitive Function	Denoting thinking processes	<i>It is up to you; you can do either way.</i>	214
		<i>We are going to; you are going to; you will; we will</i>	326
		<i>Same thing applies here; same idea here</i>	131

		<i>Sorry; sorry about that</i>	32
	Assessing listener's knowledge	<i>Thinking about this; what about this; you know what?</i>	136

The findings indicated that the majority of the pedagogical discourse markers served interpersonal functions (Table 4). Pedagogical discourse markers from interpersonal functions focus on reducing the physical gap between the tutors and the students by indicating “shared knowledge component”, “providing tutors’ attitudes about the topic explicitly”, and “providing immediate feedback and responses”. Also, a number of discourse markers were identified from the structural function. These markers suggest that the algebra tutors in the current dataset intentionally provided cues to help students feel that lecture contents are organized and structured. Lastly, two pedagogical discourse makers of the cognitive function were discovered, which attempt to “denote thinking processes” and “assess students’ knowledge”. The cognitive function discourse markers indicate that the algebra tutors tended to challenge students by assessing the student’s level of understanding regarding the lecture content. Additionally, the findings indicate that the tutors consciously communicate the lecture content by explaining their thinking processes to students for effective learning experiences.

## Conclusion and discussion

This study aimed to understand the teacher-talk strategies in the communication component from video lectures focusing on algebra content. We focused on identifying the deliberate use of word choices in video lectures and the sentiment behind those word choices in video lectures. The findings from our first analysis suggested that the word information, easability, and narrativity of the tutor’s speech, and the intentional verb choice in the communication component of the lecture videos showed distinct differences between the tutors. The results reinforced the suggestions from the previous literature, which highlighted the importance of word choices in building social partnership with the students through careful and intentional word choices (e.g., first-person plural, intentional verbs, easability of text). Moreover, the tutors’ intentional language choice significantly varied in terms of the primary sentiment conveyed in their communication component. While the previous literature emphasizes the importance of particular sentimental values, such as “enthusiasm” and “excitement” in the tutor’s communication component, the current findings discovered how the varying types of sentimental values are incorporated in the tutors’ communication component, such as “virtue”, “certainty”, and “failure”.

In our second analysis, we investigated how specific language choices occur in the form of pedagogical discourse markers in tutors’ communication components. Pedagogical discourse markers are intentional language cues that the tutors provide to convey various functions in instructional conversation (Fung & Carter, 2007). For instance, adequate use of pedagogical markers could help build interpersonal communication (“interpersonal function”), help structure, and organize the lecture contents (“structural function”) and encourage activation of cognitive processes (“cognitive function”). We discovered 17 different types of pedagogical discourse markers from the tutors’ communication component in algebra video lectures. The majority of the discourse markers served the “Interpersonal” function, which focuses on reducing the physical gap between the instructors and students by “marking shared knowledge”, “communicating tutors’ attitudes” and “showing responses to students”. Similarly, a number of discourse markers focusing on “structural” and “cognitive” functions were incorporated by the tutors to help structure the video contents, to let students denote thinking processes, and to assess the learner’s level of understanding. Moreover, the five algebra tutors showed distinct patterns in the use of discourse marker functions to convey video lectures on various algebra topics. Three different patterns of discourse marker function combinations were identified. Tutors tended to adopt the pattern representing the dominant use of discourse markers with interpersonal functions to “show response to provide immediate feedback to students. The findings in our study provide important implications for understanding and evaluating the tutors’ communications strategies in video lectures with theoretical contributions. Our findings provide new insights into how the intentional use of language in communication components occurs in real-life video lectures. The mixed-methods investigation has strong potential to provide important insights on how intentional language choice, the sentimental value of language, and the pedagogical function of the language vary in tutoring videos. This finding affords a more complete list of suggestions and recommendations for effective communication strategies in video lectures.

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