

# Learning To Communicate About Science In Everyday Language Through Informal Science Education

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**Abstract.** The University of Colorado’s Partnerships for Informal Science Education in the Community (PISEC) program, in which university students participate in classroom and after school science activities with local precollege children, seeks to develop children’s interest, identity and abilities in science, while simultaneously developing university participant’s interest and understanding in education and their abilities to communicate about science. The Communication in Everyday Language Assessment (CELA) component of our assessment suite has been used to evaluate university student teaching in these informal educational settings. We find significant positive gains a result of participating in the PISEC program.

**Keywords:** Physics education research, informal science education, pre-service training.

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## INTRODUCTION

The University of Colorado Partnerships for Informal Science Education in the Community (PISEC) [1] has developed an afterschool program as part of the JILA NSF Atomic, Molecular, and Optical Physics Frontier Center (PFC) and the Physics Education Research group at the University of Colorado (CU). Participating undergraduates, graduate students, and post docs have an opportunity to work in diverse local communities while developing teaching and communication skills.

The NSF requires the PFC to participate in “outreach activities.” In fact, many large funding agencies encourage or require grant recipients to communicate their research to the general public in some way [2], and many prominent scientists agree that such communication has become increasingly important. [3-6]. Scientists have only been marginally successful at reaching the public. [7] Journalists who report on scientific topics have been more successful, but they are not considered scientific experts whose views can be completely trusted [8].

Rowan *et al.* [9] determined that written research descriptions from 80% of 74 science graduate students and faculty from the United States, Sweden, and South Africa, were understandable to 17-year olds, although with a high degree of variability. One hour of instruction significantly improved this

percentage, leading the authors to conclude that explicit training in science communication should be an essential part of scientific preparation. We present a study that: 1) introduces the Communication in Everyday Language Assessment (CELA), part of the PISEC Assessment Suite [1], 2) demonstrates the utility of the CELA for capturing variation in participants who participate in PISEC, and 3) finds that those participants who are more actively engaged in PISEC activities demonstrate greater shifts on CELA than those who are less actively engaged.

## DESCRIPTION

In pilot work, we initially followed the Rowan *et al.* study [9] using a written assessment. After analyzing the highly varied results, we determined that written responses solicited from university participants in PISEC were not as authentic as their spoken responses, for the contexts we were working with (inquiry-based science activities in informal afterschool environments with fourth through ninth grade children). We videotaped the participants individually as a compromise between written responses and in situ videotaped sessions. Because our program supports a small number of university participants (~10) each semester, because research topics vary in explanatory difficulty, and because about half of the participants are undergraduates, we

began with a common (control) paragraph for all participants to respond to for Segment 1. This paragraph was an elementary passage from a first-year college physics textbook [10]. In this study, we only analyzed Segment 1, which is shown below including the prompt.

As part of our study about communication in everyday language, we will be videotaping you in two 5-minute segments (or less). Please think a little bit about what you might say for each segment and be prepared to present it at our next meeting. You are to speak as if you were talking to middle school students.

Segment 1. Speak about this paragraph. “The study of the motion of objects, and the related concepts of force and energy form the field called mechanics. We start by discussing objects that move without rotating. Such motion is called translational motion. When specifying the motion of an object, it is important to specify not only the speed but also the direction of motion. The term “speed” refers to how far an object travels in a given time interval. Velocity, on the other hand, is used to signify both the magnitude of how fast an object is moving and the direction in which it is moving.”

The CELA contains a second segment (not presented here), focusing on communicating about current research. Students were prompted to describe to a public audience their current research project. For students not conducting research, they were prompted to talk about how they picked their major and why science was exciting. The nine fall semester 2008 participants of this study included four undergraduates, four graduate students and one postdoc.

Participants were told to read the instructions, prepare as much as they liked (typically a minute or two), and then imagine that they were actually in front of middle school children as they spoke. This videotaped session was recorded before participants received any training in the PISEC program. During the training, participants were given feedback on their videos, specifically focused on the social contexts they were likely to encounter. For example, many participants moved very little during the exercise and used complex scientific words. PISEC training also consisted of workshops about teaching pedagogy, inquiry-based science activities, the nature of afterschool programs, working with children from under-represented populations, and science and technology content. Participants repeated the

videotaped sessions after their teaching for the semester was completed.

## CODING SCHEMES

We only analyze Segment 1 data from the nine matched pre-post assessment Fall 2009 participants. The videotaped sessions for Segment 1 were evaluated across three dimensions: Gestures, Language, and Style. These dimensions were chosen as part of communication in everyday language: Gestures can convey and emphasize meaning [11]; Language should be appropriate to the audience [12]; and Style incorporates some of the PISEC program goals in the form of enthusiasm, student centeredness, and nature of science. The dimensions and subcategories are shown in Table 1. All subcategories were scored from 0-3, and each dimension averaged over appropriate subcategories.

**Table 1. CELA Dimensions and Subcategories.**

Dimension	Subcategories
Gestures	Gesture Number, Gesture Quality
Language	Example Quality, Hard to Understand
Style	Enthusiasm, Student Centeredness, Nature of Science

The Gesture dimension was calculated for each participant as an average of the scores for two subcategories: Gesture Number and Quality. The Number subcategory was scored with a value of 0, 1, 2, and 3, corresponding to less than 20, 20-39, 40-59, 60 or more gestures, respectively. The Gesture Quality subcategory attempted to quantify the relevance of gestures (with respect to the science and also the relevance to minority, economically disadvantaged middle school children) used throughout the videotaped session. According to Scherr and others [11], “habitual hand movements ... and functional acts on objects... lack communicative intent and are therefore not gestures.” She states that large exaggerated gestures are usually used to explain ideas that are new to listeners. Thus, for the Gesture Quality subcategory (scored as an overall participant rating), a score of 0 was assigned to a flip of the wrist or other non communicative gestures as described above; 1 was assigned to relatively poor gestures that showed, for example, movement in a direction but were generally small and not well defined; 2 was assigned to relatively good gestures such as turning around or moving an object; whereas 3 was assigned to large animated gestures used directly in examples such as throwing and getting hit by a snowball.

We found good differentiation among participants for Language dimension subcategories, Example Quality and the number of references that would be hard for children to understand (Hard to Understand). The Example Quality subcategory was assigned a value based on the overall videotape transcript. For example, a value of 0 was assigned to non-existent examples. A value of 1 and 2 were assigned to relatively poor and relatively good examples. For instance, using an example of driving in a car with middle school children was not very appropriate (assigned a value of 1). Referring to Little League (which costs money to participate) with economically disadvantaged children was assigned a value of 1. However, a reference to soccer, which is common in Mexico where the majority of children were from, would be assigned a value of 2. A value of 3 was assigned to excellent, exciting, culturally or scientifically relevant examples such as throwing a snowball to relate direction and speed to velocity, which is an unusual example. The Hard to Understand subcategory was scored by counting the number of instances where the language would be difficult to understand. For example, one instance might be a long word (such as “translational,” “fundamental,” or “dimension”), an advanced science concept (such as “rotate around center of mass” or “move at a rate”), or culturally inappropriate (such as “driving a block west”). Seven or more instances was assigned a 0, while 1, 2, and 3 were assigned when the number of instances was 5-6, 3-4, and 2 or less, respectively.

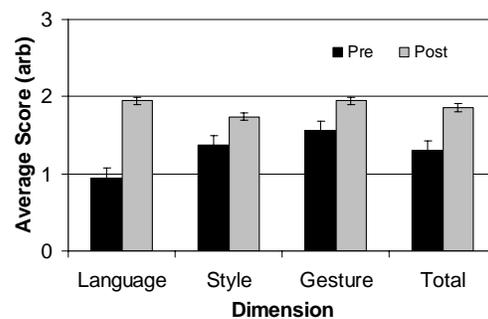
Highly differentiating Style categories included Enthusiasm, Student Centeredness, and an emphasis on Nature of Science. The Enthusiasm subcategory sought to measure how excited the participant was, with values of 0, 1, 2, and 3 assigned for very poor, relatively poor, relatively good, and very good compared to the group on average. Each video was examined in its entirety to assign values. For example, if a participant stood in one place, spoke in a monotone, and appeared bored, a value of 0 was assigned for the Enthusiasm subcategory. If the participant showed a great deal of motion, excited voice, and animated performance, a value of 3 was assigned.

Student Centered examples included asking questions of the audience, anticipating their context by referring to sports they play or objects in the room, pretending that the students answered a question and responding to it, and generally making the focus of the exercise revolve around the children as opposed to a lecture approach. The Student-Centeredness subcategory assigned 0, 1, 2, and 3 for evaluations of none at all, relatively poor, relatively good, and very good overall performance,

respectively. (Some participants had non-zero pre-assessment Student Centered scores.) The Nature of Science (NOS) subcategory assigned a 0 if no evidence was provided, while a 1 was assigned for evidence of basic NOS concepts such as “scientists want to predict...” A value of 2 was assigned for evidence of moderate NOS concepts such as how and why to perform a particular experiment, while a 3 was assigned for evidence of advanced NOS applications involving the children as scientists.

## RESULTS AND DISCUSSION

The CELA is in preliminary stages of validation; however, the preliminary results are promising. Figure 1 shows the results as an average over the participants of the pre-assessment (in black) and of the post-assessment (in gray) for each of the three dimensions (Language, Style, and Gesture) and for the Total, an average of all seven subcategories. For each dimension, the appropriate subcategory values for each participant were averaged. The standard deviation is indicated by the error bars. The Total dimension represents the seven subcategories averaged for each participant, then averaged over participants to obtain the pre and post values. The normalized gain,  $(\text{post} - \text{pre}) / (3.0 - \text{pre})$ , for the Language, Style, Gesture, and Total were 0.47 ( $p < 0.05$ ), 0.16 ( $p < 0.20$ ), 0.19 ( $p < 0.20$ ), and 0.31 ( $p < 0.05$ ), respectively. From this figure, we conclude that on average, the participants showed a statistically significant gain in each of the three categories and also overall with small post-assessment variation.



**FIGURE 1.** Pre / post Language, Style, Gesture, and Total dimensions.

Figure 2 shows the Total dimension score for each participant. The participants are ordered first by increasing level of participation in PISEC, then by self-reported experience with teaching and children. Participation was judged by the number of sessions attended and the intensity of the participation, as captured by field notes and observations. As an

example of participation ranking, Participant A only attended 3 remote sessions (in which participants talk via computer videoconference with one child and social scientists at a housing project near the University of California in San Diego [13]). These sessions can require a higher teaching skill level than face-to-face sessions. In this case the participant observed rather than participated in the sessions. Participant C also participated in the remote program, but attended more sessions (5) and observed and also participated. Participant D also attended more sessions (6) and with higher participation in these face-to-face sessions near CU with 15 children in each session. Participants D through I attended five sessions or more with a high level of participation, including working in person with more than three children in each session.

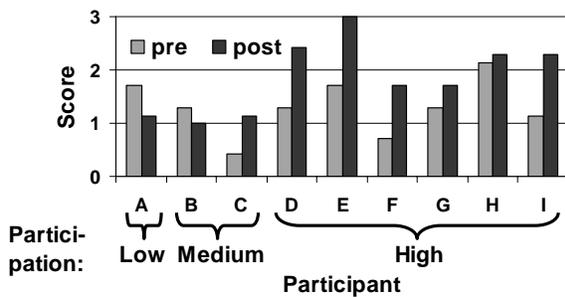


FIGURE 2. Pre / post Total dimension averaged over the seven subcategories.

For the experience ranking, a written survey about the participants' experience level with teaching and with children was administered. A low Experience Value was assigned to participants with low experience in both categories, while a high Value was assigned for high experience levels in either category. For example, the highest score for teaching experience was several semesters of graduate or undergraduate TA assignments. If the participant had children or lived with them, the highest score was assigned for experience with children.

The Low, Medium, and High Participation average normalized gains were -0.44, 0.06, and 0.52, respectively, suggesting that increased participation led to increased gain for the CELA Total dimension.

## CASE STUDIES

Although this paper's brevity precludes case studies of all participants, three participants stood out. Participants A, C, and D self reported little or no experience with teaching or children and showed normalized gains of -0.44, 0.28, and 0.67 respectively. Participants A and C attended 3 and 5

remote sessions, respectively – with A observing and C leading activities. Participant D attended 6 one-hour sessions with 15 fourth graders in person. This experience allowed Participant D to get to know the children well and anticipate approaches to get children excited. For example, during the post videotaping, Participant D used the example of an exciting snowball fight to demonstrate the velocity concepts of the given paragraph. Figure 2 and these case studies suggest that greater participation was responsible for greater gains on the CELA. Future studies will be required to further validate the assessment and collect and analyze more data on new and repeating participants.

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