

Learning English via Interactive Mathematics: Using a Multimedia Pre-calculus Program to Acquire Language Skills

Bernard Gifford
Mary Williamson
Education in Math, Science and Technology
The Graduate School of Education
University of California
4533 Tolman Hall
Berkeley CA 94720
gifford@academic.com, maryw@cogsci.berkeley.edu

Patricia Constantakis-Valdes
Academic Systems
444 Castro Street, Suite 1200
Mountain View CA 94041
pconstan@academic.com

1. Introduction

A surprising and unanticipated use of a computer-based learning environment for pre-calculus was its use by students who were already proficient in calculus but who were native speakers of Russian. When asked why they were enrolled in the course, the students told us that they were using the program to improve their English skills. What was it about the program that allowed it to be used this way? We believe that the answer lies in the fact that the program relies heavily on spoken language and all speakers are native-speakers of English. For example, all text that appears on the screens is read aloud; video clips of "peers" are provided to motivate and direct the pre-calculus student. Both these elements of the program were listened to repeatedly by the Russian students. This paper takes a look at the pre-calculus program and examines what it is about the spoken English in the program that affords practice in speaking.

We can begin our investigation by drawing on insights from ethnomethodology. Ethnomethodology has described the discourse practices of speakers as they participate in a conversation or other speech event. Particular speech events have distinct and recognizable frames, or ground rules, and draw on distinctive discourse conventions. The non-native speakers of English were using the pre-calculus program to participate in and practice speech events.

Further analysis of this phenomenon can contribute to research into and development of cost-effective computer-based learning environments which can teach content and support language learning at the same time. Further, the development of similar learning environments can have social and political consequences. For example, non-native students who have poor language skills may drain educational resources in remedial classes and still lag behind because of their lack of skills.

2. Interactive Mathematics: Instructional environment for pre-calculus

2.1. The instructional environment

The instructional environment Interactive Mathematics was developed by Academic Systems Corporation as part of the development of modules for The Mediated Learning System. At the time the native-Russian speakers were discovered to be using the pre-calculus program, it had been used by about 300 students over a period of two years under the auspices of the University Consortium for Technology-Mediated Instruction and Learning, a consortium that includes the State University of New York, the California State University and the City University of New York.

The Mediated Learning System approach to on-line instruction interleaves three factors in creating instructional environments: the *instructor* (and teaching assistants), the *textbook* and the interactive multimedia *courseware*. The Mediated Learning System approach reflects the restructuring of the traditional instructional environment, in a manner designed to enable the learner to do the following:

- i) navigate through topics and lessons over a number of distinct instructional pathways, at his or her own pace, while spending as much time as is required working on any given topic, exercise, or problem, until the appropriate level of mastery has been achieved;
- ii) receive performance feedback when it is most useful, new instruction when it is required, and extra assistance when it is needed and practical;
- iii) receive individual achievement and progress reports on a timely basis, sufficiently detailed and directive that the student becomes more adept at monitoring and regulating his or her own learning progress;
- iv) receive support from faculty or teaching assistants that is informed by detailed assessments of the individual student's strengths and weaknesses, as analyzed and reported by a specially designed learning management system; and
- v) receive *more* one-on-one and small group tutoring from faculty and teaching assistants than is feasible in the learning environment dominated by the lecture-presentational approach to instruction.

The pre-calculus program itself is a multimedia program composed of interactive modules. There are forty lessons, twenty-four for Algebra I and sixteen for Algebra II. The program is introduced by a module called The Tour, in which students are introduced to the format for the programs and in which they meet their "guide" and "peers." The Tour is the focus of most of the discussion below.

2.2. Use of the instructional environment by non-native speakers of English

The City University of New York (CUNY) made the Interactive Mathematics program available to students who enrolled in their remedial pre-calculus course during the 1993-94 and 1994-95 academic years in a lab component of the course. (An updated version continues to be in use.) Its use by students was monitored by CUNY faculty and researchers from Academic System during periodic visits. The research team informally interviewed students about their use of the program and observed students as they used the program. Additionally, they had available the data from the students' on-line pre-test of their calculus skills. From these sources, the researchers discovered that Russian-speaking students, mostly recent immigrants, were enrolling in the pre-calculus course even though they already had a solid background in calculus. The students explained their actions by saying that they enrolled in the course to practice their English. It appeared that there was an additional and unanticipated benefit might be inherent in the Mediated Learning System. These Russian students could navigate through the pre-calculus learning environment, where they knew the content but not necessarily the English with which it was presented, and listen to native speakers of English in different contexts using different speech styles.

The multimedia pre-calculus program made much more English available to these students than would have been available in a traditional pre-calculus lecture class (which they would not have enrolled in anyway). Perhaps this was a use which could be extended to other modules of the Mediated Learning System and to other instructional environments as well?

3. An analysis of the use of the multimedia pre-calculus learning environment: Insights from ethnomethodology

3.1. Analysis I: Speech events and frame analysis

Erving Goffman has described how individuals employ frameworks or "schemata" of interpretation to recognize an event and make it meaningful [Goffman 1974]. These frameworks will vary from culture to culture. Further, he points out, a cultural native is most likely to be able to unerringly use frameworks appropriately and simultaneously to be unaware that the framework exists or that an alternative framework might be possible. Frameworks might be employed to interpret the physical or social world, but we are primarily interested in the latter and we are especially interested in frameworks existing in and/or defining cultural contexts. For example, a simple occurrence like a teacher and a student who greet

one another is a common and culturally-specific speech event which occurs in a classroom setting and which is used to "set the stage" for later classroom exchanges. The initial exchange will closely resemble the following:

Teacher: "Hi, how are you?"
 Student: "Fine, thank you."
 Teacher: "Good."

At the beginning of this exchange, the speakers have expectations about what they will hear and if these expectations are met, the speakers feel at ease. If they are not, they don't. A non-native speaker who fails to respond appropriately may violate a number of cultural assumptions contained in this simple exchange concerning formality, reciprocity, turn-taking, topic choice and eye contact (assumptions which may show up differently in another language). These assumptions aren't universal but interestingly they and others *are* present in the natural language in Interactive Mathematics.

3.2. The guide: An opportunity for frame recognition

Sound is used in Interactive Mathematics to establish a framework and various speech events. The Russian speakers could listen them, becoming sensitive to their implicit assumptions. (We do not suggest that this use was necessarily conscious on the part of the native Russian speakers.) We'll illustrate this phenomenon with the text that introduces the Interactive Mathematics pre-calculus program, The Tour. Spoken English is used through the entire Interactive Mathematics suite of lessons, of course, and presumably our observations about cultural frameworks and interpretation would be applicable to speech events these events as well. The Russian speakers didn't confine their practice of English to The Tour. For this paper, however, all examples will be drawn from The Tour.

When the student selects The Tour from the Main Menu page, the screen fills with text and a movie. (We say more about the movie below.) A female native speaker of English reads the text aloud [Fig. 1]. Several aspects of the text and sound serve its function as a speech event and reflect its underlying framework as an introduction.

Example 1: A framework: Lessons in English begin with an opening statement.

The text which introduces The Tour sets the stage for the tour which will follow and the program itself. It serves the function, for a native speaker, of the initial opening remarks by a lecturer on the first day of the course, previewing the course, making the initial contacts between teacher and students and creating the classroom atmosphere. Pragmatically, it signals to the student that instruction will follow and indicates that the student should pay attention to what will follow. In other words, it establishes a framework.

Example 2: A typical speech event: The semantic coherence of the text and sound work together to introduce a new event and information. In English, speakers listen for stress on the important information. The first noun in a speech is stressed, indicating a new topic and other noun phrases may also be stressed, but less so, indicating an elaboration of the topic. This is the pattern in Interactive Mathematics. *The guide says:* "The TOUR ... an overview of how to USE IT and how to get the MOST from it"

Example 3: Topic progression during the speech event: Topic progression moves from general to specific and from primary to secondary. This progression is typical of English [Tab. 1].

General Topic:	"The Tour is designed to provide you with an overview"	Primary Info:	"how to get the most from ... course"
Specific Topic:	"you will hear from students"	Secondary Inf.:	"each one has things to share with you"

Table 1: Semantic progression in introductory text

Example 4: Common American cultural assumptions that appear in the guide's speech: There are several assumptions about the context and content of conversations embedded in the guide's speech.

Assumption:	Example:
tour metaphor suggests stops across a domain	"proceed <i>thorough</i> the tour"
people will help you	"each one (a peer) has ideas to share with you"
people have many different reasons for their actions	"each ... is taking course for a different reasons"

Table 2: Cultural assumptions in the guide's speech

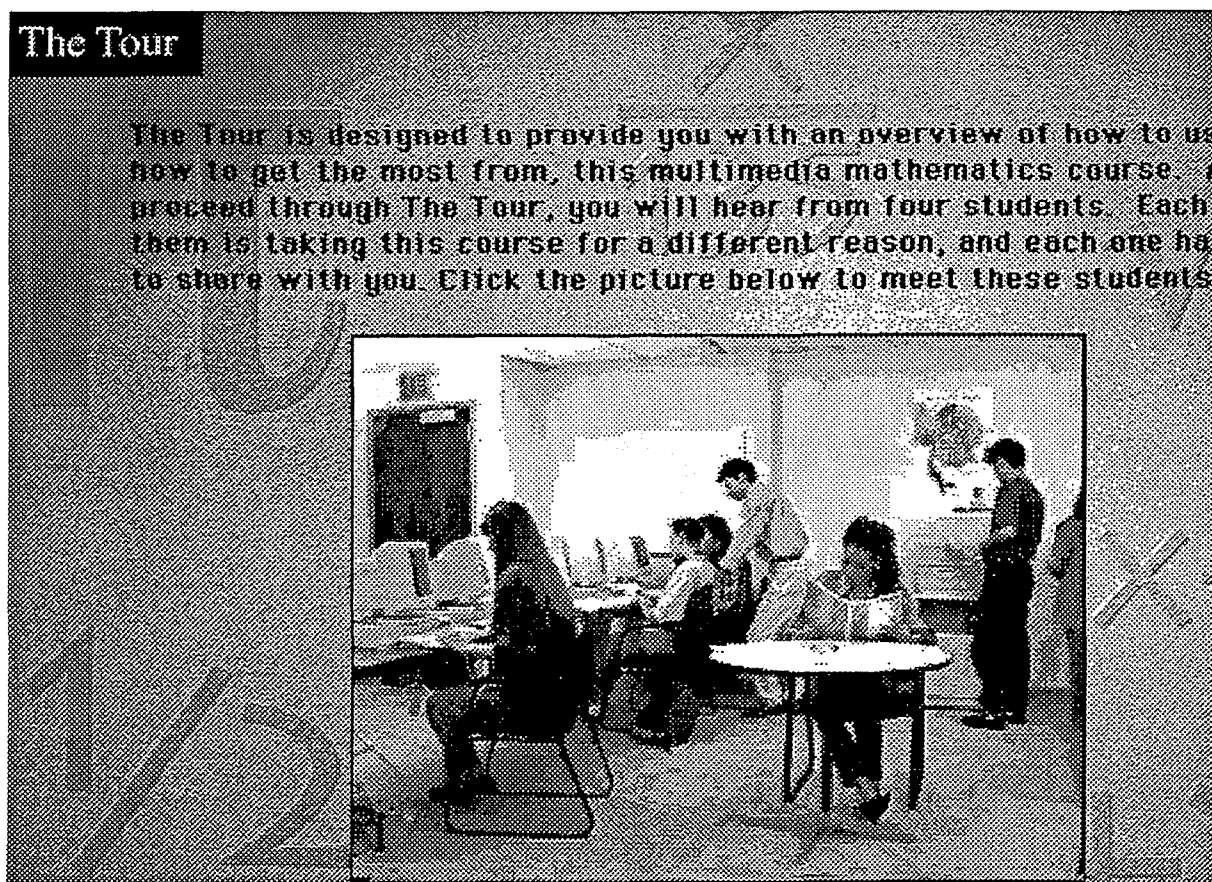


Figure 1: Introduction to pre-calculus program

3.3. Analysis II: Language cues and cultural conventions

It has been suggested in anthropology that culture may be defined as a set of "underlying standards by which we judge behavior," a notion very similar to that of frameworks. [Gumperz 1988]. Conversation analysis has ferreted out some of the underlying assumptions of English [Gumperz, 1988] and described their culturally-specific and lexical and semantic enactment [Gumperz 1982; Gumperz 1988]. For example, even a native speaker of British English and a native speaker of Indian English may misunderstand each other if the assumptions underlying their words aren't the same.

The following brief exchange illustrates this phenomenon. Speaker A is an applicant for a job course and a native speaker of Indian English. Speaker B is a job counselor and a native speaker of British English. Speaker B attempts to start the interview but Speaker A interrupts.

Speaker B: Tell me what you want.
Speaker A: May I first of all request for the introduction please.
Speaker B: Oh yes sorry. [Gumperz 1988]

In the British and American culture, we would expect a job counselor to set the pace and content of the interview. However, Speaker A, a competent speaker of English, appears not to share this assumption. Further, Speaker A puts Speaker B into a position of needing to apologize, which would be considered bad form by a native British (and American) speaker. Both Speakers A and B leave ill at ease. Interactive Mathematics appears to have provided the Russian speakers with a non-threatening context for "interacting" with native speakers in order to confirm and disconfirm their conversational assumptions.

3.4. The "other students": An opportunity to talk with peers

In Interactive Mathematics students encounter simulated dialog situations in which native speakers of English appear as if they are in a conversational exchange with the student using the program. This provided the Russian students with important verbal, prosodic and non-verbal contextualization clues to how such exchanges normally take place in English. We'll provide some examples.

Example 1: The student is greeted by a peer. On the first screen of the Tour [Fig. 1], the student watches a video. At first, the peers in the video are working (and there is background music). Then the video focuses on one peer who looks up, faces the student, the camera moves in, and the student starts to speak [Fig. 2-a].



Figure 2 -a: Speaker uses typical English verbal and non-verbal cues

Non-verbal cue: When the peer starts to speak, she fills the screen as if moving into the "proper" distance from the student to begin a conversation and she maintains eye contact with the student while she is introducing herself, creating a friendly conversational presence.

Prosodic cue: The student says, "Hi, I'm Sarah Richards." This is a typical introduction in American English -- the "hi" precedes the name, the name is given before any other information and the full name is given.

Example 2: The student listens to a peer. During the tour, the student is introduced to the lesson format via video presentations of four "peers," similarly encountered in a video format.

Contextualization cues established: In our video, the peer refers to the side of the screen, facing the student and follows a common pattern for establishing context in English. He tells the student where to look on the screen ("on the left of the screen") and then moves down the screen, reading the list of buttons on the screen ("overview, explain, apply, explore, evaluate, and framework"), pausing slightly at each button to let the student focus on it.

Contextualization cues used: After the peer has described the screen, he refers to it. It can now be presumed to be familiar to the student and has been established as a framework of interpretation for the entire program.

4. Future directions

Our analyses leads to several suggestions for future design of instructional environments. First, since it is important for all students to pick up the discourse of a community and since this has been shown previously to be particularly important for non-native speakers of English [cf. Kramsch 1993], the designer of an environment should supply sound and pay special attention to using speakers who are native speakers of English. Second, non-native speakers can benefit from the opportunity to hear the English spoken by native speakers in learning environments not primarily designed for second-language acquisition and they should be encouraged to use these environments even when they already "know" the content. Third, "peer encounters" can give all students lots of opportunities to respond to natural, competent English. Other research has shown that the way tutors manage language during tutoring sessions has a significant effect on tutoring effectiveness [cf. Person et al 1995]. The designer should construct tutoring opportunities, using sound, which use English effectively.

It should be noted that adding sound is a change which is relatively minor in terms of production but which can have significant consequences for creating software to meet multiple goals. Additionally, adding sound addresses the needs of non-native speakers of English, an often ill-served and expensive community in higher education in mathematics. Finally, adding a framework to instructional environments, such as that established by The Tour, serve to set the stage for a lesson for all speakers and to familiarize the non-native speaker with an important speech event in English.

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