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Author: Novemsky, Lisa; Gautreau, Ronald & Pallrand, George

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Second Teaching:
A Vygotskiian Approach to Constructing Understanding in Physics Learning

Lisa Novemsky
Rutgers University
USA
973 763-8293
novemsky@admin.njit.edu

Ronald Gautreau
New Jersey Institute of Technology
USA
973 596-3556
gautreaur@admin.njit.edu

George J. Pallrand
Rutgers University
USA
732 932-7496 x101
pallrand@mbcl.rutgers.edu

Completion Date: 9-12-1997

ABSTRACT

Limited language proficiency within an academic discipline may be seen as making significant and potential contributions to formation and proliferation of misconceptions within that discipline. In this paper, second teaching, a pedagogical approach to addressing language aspects of introductory learning experiences, is described. Second teaching, based on the ideas of L.S. Vygotsky, is a model of structured small group activity which follows an initial presentation of new material, or first teaching. Although second teaching appears relevant to many domains, this work was generated from the specific domain of introductory physics learning involving students with limited English language proficiency.

Second Teaching: A Vygotskiian Approach to Constructing Understanding in Physics Learning

Lisa Novemsky
Rutgers University
USA

Ronald Gautreau
New Jersey Institute of Technology
USA

George J. Pallrand
Rutgers University
USA

Completion Date: 9-12-1997

> Speech harbours the seeds of the structure of the human intellect (Snell, 1960, p. 245).

1. INTRODUCTION

Each academic discipline presents its own language. An individual can be recognized as accomplished in a discipline when and only when that person is seen to be somewhat fluent in accurate reasoning, description, and explanation. At introductory levels, these academic languages often present a challenge to novice learners. Thus, language learning in an unfamiliar academic discipline involves processes similar to learning a second or foreign language. Development of a second language processing system within a particular discipline entails a deep learning involving multi-modal aspects.

Language factors appear to make significant contributions to formation and proliferation of conceptual understanding and ability to reason within conventions of a particular academic discipline. Limited language proficiency within such a discipline, therefore, may be seen as making significant and potential contributions to formation and proliferation of misconceptions within that discipline.

In this paper, second teaching, a pedagogical approach to addressing language aspects of introductory learning experiences, is described. Second teaching, based on the ideas of L.S. Vygotsky, is a model of structured small group activity which follows an initial presentation of new material, or first teaching. Although second teaching appears relevant to many domains, this work was generated from the specific domain of introductory physics learning involving students with limited English language proficiency.

2. SCIENTIFIC LANGUAGE

Scientific discourse developed in a historical context which is linked to classical Greek language and culture.

> The formulation of scientific concepts and technical terms is restricted to the limits set by speech, and this means that it was geared to the level of development which the Greek language had reached. It also meant that the choice of terms and concepts was determined by the amount of forms available in the language....The thought of natural science represents only one of the categories with which our speech operates. But its development in human thought has been so purposeful that no other body of concepts, no other terminology has removed itself equally far from the expressions of ordinary language (Snell, 1960, p. 244-245).

As scientific language evolved from its Greek foundations, it remained highly formalized, conventionalized and standardized as to connotations and meanings of word with a high degree of semantic consistency. In each scientific and technical domain, language is discriminative and specific as to name, feature and category of referents. Historically, scientific words have had a high degree of permanence, as well as singleness of meaning, and marked constancy in form and function (Hertzler, 1965, p. 353). In physics, for example, words like "force," "reaction," "law," "normal," and "body" are transformed from their rich colloquial forms, with multiple connotations, to be recast in scientese with rigorous specificity, typically endowed with rule-based quantifiable qualities.

> Scientific knowledge is a model of rationality. All scientific knowledge is contingent and must be justified by means of evidence or reasons. It is just such knowledge that students should be taught to aspire to...and the student must be educated to seek that organization so that no claims of fact will be made without evidence, no opinions will be proffered without accompanying reasons, and no judgments will be made without appropriately relevant criteria (Lipman, 1991, p. 18).

Hertzler (1965, p. 351) has suggested that some of the language in daily use is of limited value in dealing with science. In large part mastery of science includes proficiency in specialized ways of using language (Lemke, 1990, p.21). Induction into a science community, especially for learners with limited language proficiency, means learning science as a second language. Complex cognitive and linguistic skills must be mastered by students who find this abstract, objective, precise, logical, quantitative realm rather foreign. Understanding science concepts, for example, involves instantiation of a specialized mode of experiencing, defining, categorizing, describing, and explaining the world.

3. PHYSICS LANGUAGE

Physics is built on strict logic. Discourse for effective communication of physics ideas requires a high degree of syntactical logic as well as highly skilled use of scientific vocabulary, images, metaphors, and analogies. In order to facilitate unambiguous communication of detailed, specific information, physics discourse is logical in its presentation and generally unemotional, exact in definitions, and exclusive of any other than single and specifically assigned meanings. Physics discourse is cautious, not flamboyant, arbitrary, or dogmatic, and usually economical.

Physicists and other technical people tend to use full noun phrases or shortened versions repeatedly rather than pronouns to avoid imprecision and possible ambiguity (Huckin & Olsen, 1991, pp. 480-481). Beginning students, in contrast, tend to speckle their discourse with indeterminate pronouns to cover insecure knowledge or terminology (Novemsky, dissertation in progress). Orr (1987) reports observations of students with limited language proficiency mistaking qualifiers for that which is qualified and vice versa, nonstandard uses of prepositions and conjunctions, and systematic errors in comparative grammatical structures. According to Orr's observations these nonstandard language uses are accompanied by nonstandard perceptions of time, distance, and other mathematical and scientific concepts.

4. LANGUAGE GAPS IN PHYSICS LEARNING

There is a significant gap between formal and precise language of postsecondary physics education and informal vernacular of many physics learners. Such a language gap poses a challenge to students who are in a process of developing conceptual understanding of physics ideas along with physics reasoning skills. Formal and precise language structures and vocabulary of scientific discourse tend to be distant from physics learners and distinct from their natural language of peer culture. Precision in lexical and syntactical aspects of physics language is necessary in order to sharpen understanding and communication of clear distinctions and complex relationships which are critical components of any technical discipline.

To many students standard English enhanced with technical scientific parlance presents severe difficulties similar to confusion encountered when confronted with a totally foreign language (Lemke, 1990; Orr, 1987). If this language gap is not addressed, critical language-related misconceptions are likely to occur. In order to facilitate physics learning for *all* students an intervening process may be appropriate.

Physics learning is equivalent to tuning in to a second culture with unique practices and specialized language. In learning a second language, immersion and rehearsal provide an environment for attunement that refines language usage, that facilitates ease and natural flow. Similarly in learning physics, immersion and participation, learning by practice and approximation rather than passive reading and listening, becomes a logical prescription.

5. SECOND TEACHING: A VYGOTSKIIAN APPROACH TO PEDAGOGY

A study of students with limited language proficiency who were engaged in a process of learning introductory physics has been undertaken by Novemsky (dissertation in progress). The study was focused on language factors in conceptual physics learning while students were participating in a model program titled *Overview, Case Study Physics* (OCS Physics).

OCS Physics was developed primarily by Alan Van Heuvelen (1991a, 1991b, 1991c) of Ohio State University. Data from OCS Physics programs at New Jersey Institute of Technology show dramatic increases in student learning (Gautreau & Novemsky, 1997). OCS Physics is built upon two mutually complementary interactive educational practices that deviate from conventional postsecondary physics instruction. The first aspect of OCS Physics involves order of presentation of subject matter. Physics concepts are taught first, with essentially no mathematics. Only after the concepts are understood is the necessary math brought in at the appropriate level.

A second and crucial aspect of this pedagogy, which is the major theme of this paper, is small group work. Students work collaboratively in small groups of 3 or 4 on guided problem solving tasks called *Active Learning Problem Sheets* (ALPS) developed by Van Heuvelen (1991a). The problem sheets have been specifically designed for conceptual understanding through small group collaboration.

After three years of intensive observation and student interviews, Novemsky (1994) developed a theoretical construct, *second teaching,* which describes theoretical and practical aspects of guided small group problem solving following an initial presentation of new ideas, or first teaching. Second teaching is based on ideas presented and explicated by the Russian psychologist and literary scholar Lev Semyonovich Vygotsky (1896-1934). In addition to language serving as a medium of communication of thought, it was Vygotsky's idea that language also serves as a tool and cultural means for developing logical and analytic thinking and learning (Vygotsky, 1934/1962). Vygotsky emphasized highly complex dynamic relations between developmental and learning processes. He argued that learning processes are converted into internal developmental processes in a "zone of proximal development:"

> [The zone of proximal development is]...the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1935/1978, p. 86).

In a zone of proximal development, cognitive growth proceeds through participation in activities slightly beyond competence levels of an individual. In second teaching the collective wisdom of a collaborative group, somewhat beyond the level for each individual member, but within the zone of proximal development of individual group members, is created then recreated through self correction.

Second teaching facilitates a learning process for students who find a new discipline with its optic (way of seeing) and language foreign. In informal small group settings students describe, explain, elaborate, test, and defend ideas in their own familiar vernacular as they collaborate in understanding concepts and solving problems. Students practice new language usage in a natural context of learning new concepts and applying new skills. Novemsky's investigations have suggested that as second teaching progresses students improve significantly in new knowledge and new language usage (Novemsky, dissertation in progress).

6. CONCLUSION

Second teaching provides opportunity for conversational apprenticeship in technical discourse (Lipman, 1991, p.40) . Conversational apprenticeship refers to a process by which students are gradually initiated into the skills and partnership of ongoing dialogue in small groups. Conversational apprenticeship in second teaching is facilitated by the group itself. In its collective wisdom, a small group acts as a mentor to its individual members since a group has the potential to operate just above the level of acquired knowledge within a group member's zone of proximal development.

As Brown and Palincsar (1989, p. 395) indicate, change is more likely when one is required to explain, elaborate, or defend one's position to others, as well as to oneself. When new and difficult concepts and tasks emerge in a group, dissident, and mutually incommensurate ideas tend to be generated. Cognitive conflict and dissonance (Festinger, 1957) that ensues provides the opportunity for group grappling and learning. In an effort to resolve conflict or dissonance, such a situation calls forth the need for convincing explanatory discourse.

> In a dialogue...disequilibrium is enforced in order to force forward movement. One cannot help thinking of the analogy with walking where you move forward by constantly throwing yourself off balance....Each step forward makes a further step forward possible; in a dialogue, each argument evokes a counterargument that pushes itself beyond the other and pushes the other beyond itself (Lipman, 1991, p. 232).

In a small group setting, individuals often discuss differences and argue in the natural language of their peer culture. Gradually, in small approximations, the language structures and vocabulary of a new discipline begin to emerge as learners use aspects of the rhetoric of logical argument, integrated with their previous language base, to defend their positions.

In the course of this engaged learning activity, language and conceptual understanding are nurtured simultaneously. Understanding is constructed in a milieu of language generated by learners. In this informal setting natural language of peer culture is spoken along with technical jargon. New learning is integrated and re-integrated into a substrate of comfortable language and ideas. Misconceptions are likely to be subjected to self-correction in an iterative process of second teaching as the collective wisdom of a group gradually integrates knowledge and conventions of physics in a process of second teaching.

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BIOGRAPHIES

Lisa Novemsky is completing her doctoral studies in science education with Dr. George Pallrand at the Graduate School of Education of Rutgers University, New Brunswick, New Jersey. She has an extensive career of university teaching and administration and has published widely in the fields of educational theory and practice.

Ronald Gautreau is a Professor of Physics at New Jersey Institute of Technology in Newark, New Jersey. He is the recipient of several teaching awards as well as research awards for his work in relativity and relativistic cosmology. He has published widely in the fields of relativity and physics education.

George J. Pallrand is Professor of Education at Rutgers University in New Brunswick, New Jersey. He also holds an adjunct position at the Waksman Institute at Rutgers University. His professional interests concern bridging the gap between the research community and the public culture through the schools.