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Inscriptions and their interpretation in schools and at work

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Abstract. This study was conducted to answer the question, "What is the relationship between inscriptions (graphical representations) that accompany written text in available resources and the associated interpretive practices?" We analyzed 6 high school and 5 university textbooks, and over 2,500 pages of scientific journals. We also conducted nearly 100 interviews related to inscriptions. At a most general level, we found (a) a continuous change in the frequencies and types of graphical representations that occur in the texts available to high school students, college students, and research scientists; and (b) there is a discontinuity in the interpretation practices which occurs after individuals have engaged in their own research for some time. If this decalage was addressed in teaching, we may be able to observe changes in students' competencies related to the perusal of inscriptions.

Theoretical Framework and Purpose. An increasing number of studies over the past decade have highlighted the pivotal role that inscriptions (various graphical representations) have in the conduct of science (e.g., Lynch & Woolgar, 1990) and in the claims that science makes. Our research agenda is concerned with the development of scientific practices including research and representation practices; this research is grounded in a phenomenological view of knowing as social practice (Roth & McGinn, 1998). As part of this research, we examined (middle school, high school, university) student competencies in interpreting graphs and contrasted their analyses with those of "scientists" who conduct their own field research and how they use and interpret inscriptions (Roth & Bowen, in press). Text resources constitute a common experience of individuals in schools as they learn about science and thus, an examination of these resources, provide a foundation for discussing the competencies of these individuals in their conduct of scientific practices—such as interpreting graphs. Since science teaching at almost all educational levels is dominated by textbook-oriented approaches, we investigated the use of inscriptions in different texts available to individuals at their level of training (textbooks, journals) and the interpretive practices of individuals at the same level.

Design, Procedure, Data Analysis. *Inscription Sources and Analysis*. Our selection included three of the four most representative biology textbooks. Our selection of college ecology textbooks represent the major textbooks used to teach second to fourth year ecology courses at Canadian and American post-secondary institutions. We selected five highly regarded journals ecology journals indicated both by formal (citation indices) and informal (biology professors) indicators.

Interviews with Participants. The data base on which our study rests includes videotaped interpretation sessions from Grade 7 to professional practices amounting to over 100 individuals (including over 20 scientists). In these interviews, the participants were asked, either individually or in small groups, to discuss how they would interpret different inscriptions (representative of different graphical inscriptions found in the textbooks). Transcripts of interviews were made in an on-going fashion as the interviews progressed.

Analysis. All records were subjected to an interpretive text analysis grounded in semiotics and hermeneutics (Ricúur, 1991). We independently conducted interpretive analysis of the data to determine tentative interpretations. Through repeated cycles of interacting with each other and independent analysis, we identified dis/confirming for our tentative interpretations leading to further increasing refinements of our claims.

Summary of Data Analysis. This study is situated within our research program that is concerned with the social, demonstrable, and naturally accountable aspects scientific representation practices. Most generally, we conclude that there is (a) a continuous change in the frequencies and types of graphical representations that occur in the texts available to high school students, college students, and research scientists; and (b) a discontinuity in the interpretation practices which occurs after individuals have engaged in their own research for some time. We concluded that graphical representations in scientific texts are easier to interpret and less ambiguous than those that appear in high school or college texts. Thus, the trajectory of interpretation competencies is not paralleled or supported by the materials generally available to individuals.

Inscriptions that Accompany Text. There is a marked change in the use of inscriptions as the inscriptional resources progress through the educational system (Figure 1). (For brevity's sake, only some of the comparisons are graphically made.) High school textbooks generally emphasize photographs and diagrammatic resources. Journals generally emphasize scatterplots and equations. College-level textbooks, although they use photographs, generally emphasize scatterplots and histograms (not illustrated). College texts were found to use some types of inscriptions (such as diagrams, maps, graph models, and histograms) more frequently than either high school texts or journal articles. Several of the types of inscriptions (notably; equations, scatterplots, and tables) showed a gradual increase in frequency from high school texts to journal articles. Similarly to our past findings with journal articles, inscriptions in college textbooks are embedded in the overall text with interpretations of the inscriptions usually provided in either the caption or the main text, unlike in high school textbooks which did not usually provide such an interpretive framework for the reader.

Interviews with Participants. Our analysis of participants' interviews suggests that the interpretations of graphs by students with science education at the Bachelor's level are unlike those of participants who had participated in conducting, analyzing, and interpreting field research. There appeared to be few differences in interpretations between students who had only studied science from high school texts (non-science majors attending college) and those who had studied science as undergraduate science majors. The increase in complexity in inscriptions in textual resources used to teach science at increasing educational levels is not paralleled by an increase in interpretive

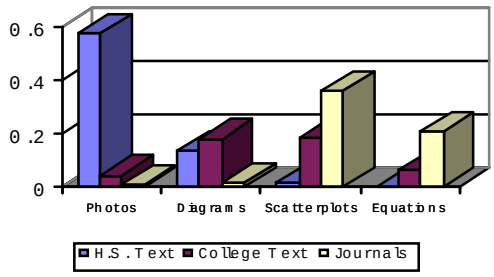

Figure 1. Excerpt from representation of the change in representation in three textual resources in the domain of ecology: high school textbooks, college textbooks, and scientific journals.

competencies of those who are using those resources as they progress through the educational system. Our data suggests that the discontinuity occurs when a person begins do her own research from which she is trying to rhetorically construct a scientific claim or argument. Furthermore, the differences were not so much due to differences in interpretation “skills” than to the extent of the (personal or vicarious) experiences of natural world that individuals use as counterparts to the graphical representations. Thus, for example, whereas scientists used their extensive experiences with several natural animal populations to interpret birth rate and death rate graphs in a cyclical process from graph to population, even college students had few such experiences that would help them to make sense of the graph. At best, they were able to fabricate one or two hypothetical sample populations which were not enough for a satisfactory interpretation. On the other hand, we observed tremendous data and graph interpretation competencies among Grade 8 students who had extensive experience in field research and who used this situated knowledge to elaborate the meaning of graphical representations.

Educational Significance.

The increase in complexity of inscriptional resources is not paralleled by an increase in interpretive competencies. This suggests that it is not the exposure to more complex inscriptions in textbooks which leads to the development of competency in interpreting these resources. Earlier work among Grade 8 students (Roth, 1996) documented their development in framing field studies and constructing their arguments through the use of various types of inscriptions. It is through their engagement in their own research from which they constructed arguments to convince others in their scientific community that extraordinary competencies in the use and interpretations of inscriptions developed. We therefore conclude that it is not sufficient to “tell” students in lectures or textbooks how or where to use particular inscriptions, or how to interpret them. To effectively learn to use and interpret inscriptions, whether in an undergraduate education or a science program , student need to participate in long term, independent inquiry project oriented courses with peer review and critiqueóand this will address both content and process issues of their science backgrounds.

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