OPENING UP EXPLANATION TO EMERGENCE

Khadeeja Ibrahim-Didi

University of Alberta, Edmonton, Canada

It is human to explain our experiences (Maturana, 1988; Keil & Wilson, 2000). In explaining we define meanings and truth. This study explores how explanations are validated in public domains. It focuses on how interactions in public domains such as socio-political arenas and classroom science in developing explanations are constrained by what counts as evidence. Further, the study pays attention to how the topology of interactions in which explanations emerge shape them as they unfold. In this way the study proposes that research in the nature of explanation as process is a crucial aspect for informing the education of citizens for participation in the public arena.

INTRODUCTION

The nature of explanation

Etymologically, the word *explain* refers to spread flat, to unfold, or to give details or assign meanings. This laying flat defines what meanings may be associated with what is being explained and excludes or includes certain groups in the domain of explanation. The validation of any explanation is therefore determined in the community of practice in which it emerges and therefore points to the dynamics which brought it into being. The etymology of the word *explanation* refers to this process of reconciliation of differences and therefore the consensual fixation of meaning.

Explanation, science and school science

One of science's greatest contributions to humankind is its ability to explain natural phenomena (Popper, 1983). In providing explanations for humankind's experiences, it has transcended epistemological roots to attempt to explain meanings of existence through Darwinian analyses and the theory of The Big Bang. In the scientific domain, explanations produced as theories and models are corroborated as truth based on empirical evidence. Given the accomplishments that scientific truth has enabled, in terms of medical and other technological development scientific explanations, the significance of the realist/antirealist debate can become weighted heavily towards the realist camp. And yet, a realist interpretation of a scientific explanation assumes the possibility for all causal variables to be taken into consideration and must render the evolution of the world static.

On the other hand, the role of interpretation, and the creative aspects of science cannot be undermined in the possibilities afforded by conceptual leaps such as the Pasteur's germ theory which constitutively changed the explanation of diseases. Studies of science propose that evidence is fixed in community as empirical through interpretation of what counts as significant data (Amann and Knorr-Cetina, 1988; Latour, 1990). Therefore, the centrality of creative abduction in scientific discovery is paramount. The question is how creativity and reality may be understood in scientific theorizing and how the consequences for explanation in science might be imagined.

The issue of scientific explanation is further aggravated when taken up in the context of school science. There seems to be a lack of agreement as to how scientific explanation may be encouraged

in classrooms. Constructivists with their focus on student learning argue that students construct their explanations and therefore science education should focus on this aspect (Newton, Driver and Osborne, 1999). The realist rejoinder identifies that scientific explanation is validated by its correspondence to reality and hence science teachers must re-present explanations that are already considered true to students so that they may be inducted into the practice of science (Matthews, 1998). The epistemological and ontological roots of these two incompatible positions problematize understandings of scientific explaining in schools.

Explanation, truth and power

In the public sphere, the conflation of epistemology and ontology can be appropriated by political and other ideologies for the purposes of defining truth. By defining truth as being based on reality in the objective static sense, explanation can be a means to subjugate groups of people. In this particular study the simultaneous consideration of explanation in classrooms and socio-politic arena highlights how the conceptualization of evidence in the different domains was central to the explanation that was consolidated. Further, modes of interaction used to assist other explanations to emerge in the domain were explored.

OBJECTIVES OR PURPOSES

This study explores the nature of scientific explanations in school science classrooms by asking the following questions:

1. How do scientific explanations evolve in classrooms?
2. In what ways are these explanations constrained?
3. How do these constraints shape explanation in different domains?

PERSPECTIVE(S) OR THEORETICAL FRAMEWORK

This study is framed through recent Complexity-Theoretic understandings in cognition, and reconciles process and product-based views on explanation without necessarily prioritizing either. Complexity Theory focuses on how random, local interactions can self organize by evolving into emergent structural forms (Johnson, 2001). This process is of the bootstrapping sort where no external force directs the form of the emergent structure. The newly emergent level structure demonstrates features unique to itself and is more than the sum of its parts. It acts as one identifiable structure in interacting with other agents on increasing levels of complex organization.

The cognitive equivalent, Enactivism identifies the inextricability of knowing from doing and being for any complex system. Knowledge is perceptually guided action (Varela, Thompson and Rosch, 1991). The ability for an organism to continuously maintain its own identity as well as a co-evolving relationship with the environment through its actions is seen to be the mark of a living system (Maturana and Varela, 1992). In this view learning and living are seen to be synonymous. The ability of a system to adapt to environmental triggers as its parts produce's its structure are one and the same process. (Davis, Sumara and Luce-Kapler, 2000) extend this view of living and learning in complex terms to embed emerging adaptable structures in other organizationally more complex learning systems. In this way, they identify a student as an emergent learning system, constituted by self-organizing biological subsystems. The classroom is considered an emergent

learning system of which the student is an integral constitutive interactive part. The Earth itself is ever evolving, and therefore a learning system, embedding larger social systems.

The ontological consequence is the view of reality-in-the-making. Contrary to the commonly held view of a static, recoverable reality, this view confronts how scientific or any kind of explanation may be conceptualized. Instead of choosing between views of explanation as representation or as a means to "introducing order" onto the world, the view adopted in the study disrupts the dichotomy by considering a middle path (Tibbetts, 1990). This positioning is not a conciliatory view, but a radical repositioning of the embedded knowing systems. Accordingly, the consequent influence of human actions as afforded by domain specific explanatory constructs on the unceasing unfolding of the world is considered. It is this critical aspect that Enactivism affords an understanding of scientific explanation: that janus-faced, explanation as representation acts as if it represents something for someone, who acts in the unfolding of that which is represented. Explanation is a way of bringing forth the world meaningfully (Simmt, 2000).

It is important to recognize that from this perspective, the explaining system nested in the explained system co-evolves together and any explanatory representation is necessarily out of date. This paradox allows different insights into scientific explanation in classrooms.

Enactivism offers us a way to bridge the separation of the explained and explaining by reconnecting physical reality and cognition. In addition, it brings together explorations of psychological and sociological research on explanation respectively. Individualistic approaches to explanation focus on explanation as statement (Ogborn, Kress, Martins and McGillicuddy, 1996; Grotzer 2003). On the other hand, sociological approaches emphasize how explanations are consensually driven (Meyer and Woodruff, 1997; Coleman, 1998). On a Vygotskian note, the explanations of individual students are viewed in light of the possibilities (both enabling and constraining) afforded by the conversational interactions in the collective domain (Gordon-Calvert, 2001). The collective cognitive space can be said to map the topological domain available for paths of reasoning to follow. Further, this study questions how physicality of experience might define the re-presentative aspect of explanation.

The research framework allows a simultaneous consideration of these approaches to better understand the phenomenon of explaining. In this way, the study is able to transcend understandings of explanations as arising from linear lines of inductive or deductive reasoning. The opening up of the theoretic framework to classroom conversation allows consideration of creative, abductive influences of triggering thoughts, ideas and actions semiotically alongside deductive and inductive modes of validating such explanation (Peirce, 1957).

MODES OF INQUIRY

This presentation reports on a case study. In keeping with the conceptualization of knowledge as action, the methodological basis for the study is hermeneutic (Gadamer, 1989). The constructive aspect of recursion in the engagement with interpretation is embraced (Smith, 1991; Ellis, 1998; Maturana, 1988). The study draws particularly from Lemke's topological and typological semiotic approaches to understand how interactional dynamics are central to the meaning that emerges as explanations (Lemke, 1999). More specifically, a semiotic interpretation helps to frame the semiotic

constraints that are negotiated on a moment-to-moment basis in the evolution of explanatory understandings.

The analysis of the data is grounded interobjectively, by considering the observed as a function of the observer, constrained by the physical interactive resistance of the world (Maturana, 1988). The second order cybernetic approach to observation is ethnographic to attend to social and cultural significances that might be at play in the interactions between the participants (Bogdan and Biklen, 1992).

DATA SOURCES

In this study, students and the teacher in two junior high school science classrooms in the Republic of Maldives were observed for a period of a month. In particular, the dynamics that constituted explanations in small group and whole-class situations were focused on. During the course of this time conversations were conducted with two groups of students that were observed in the two classes. These observations were video taped and transcribed. The video tapes were analyzed semiotically, with reference to utterances as well as actions. Students' written work was also collected and analyzed

Throughout this period, three conversations were conducted with the teacher. Two Assistant Principals and the Physics Head of Department of the school participated in the study through informal conversations. Field notes were used to annotate the observational video data. Other contextual data about the social system was documented in the form of field notes and collected from available news papers produced by different ideological groups.

CONCLUSIONS

The study identified how the structural organization of interaction was key in the type of explanations that were possible. Authoritative regulation of interaction, structure of activity can significantly influence the role abduction, induction or deduction can play in classroom conversations. Cultural modes of interaction impact the types of reasoning practices that are manifest in classrooms.

Significantly, findings revealed that the criteria with which explanation is validated depend on the type of interaction that constitutes the explanation. Analysis of small group interactions showed that explanation constructed were constrained and enabled by conversational implicatures around the significance of evidence (Forman and Arreamendy-Joerns, 1998). The meandering path of the conversation itself shaped the nature of the explanation that arose (Amann and Knorr Cetina, 1988). The analysis of explanation understood as emerging from collectives also re-configured explicative moments. These moments opened up the emerging explanations as ongoing semiotic activity. Every explicative moment provided further possible paths for the explanation to evolve.

In the event of teacher centered constructions of explanations, the structure of the unfolding interactions tended to confirm explanatory statements. The explanation was determined by the authority of the teacher. Evidence was used as a deductive and inductive prop for the establishment of the explanation.

In the social context, considering explanations as starting points of further elaborations, it became clear that instances for public participation in political explanations were made possible.

SIGNIFICANCE OF STUDY

This study highlights how the nature of interaction might enable certain ontologies to be confirmed. An enactive ontology of a world incessantly coming into being is supported by non-authoritarian, abductive, interpretational approaches to explanation while more authoritative structures of interaction support the two sided argument that supports either the real or the anti-real view.

The study highlights how explanation can be seen as momentary stops that facilitate how students, teachers and the larger public can engage in emergent explanations. Further it emphasizes the need for educators to pay attention to how the semiotic topological domain moulds the explanations that emerge in classrooms.

References

Amann, K. and Knorr-Cetina, K. D. (1988). The fixation of (visual) evidence. *Human Studies 11*, 133-169

Bogdan, R. C. B., S. K. (1992). *Qualitative research for education*. Boston: Allyn and Bacon.

Coleman, E. B. (1998). Using explanatory knowledge during collaborative problem-solving in science. *Journal of the Learning Sciences, 7*, 387-427.

Davis, B., Sumara, D., & Luce-Kapler, R. (2000). *Engaging minds: Learning and teaching in a complex world*. Mahwah, NJ: Lawrence Erlbaum Associates.

Ellis, J. L. (1998). Interpretive inquiry as a formal research process. In J. L. Ellis (Ed.) *Teaching from understanding: Teacher as interpretive inquirer* (pp. 15-32). New York: Garland publishing Inc.

Forman, E.A. & Arreamendy-Joerns, J. (1998). Making explicit the implicit: Classroom explanations and conversational implicatures. *Mind, Culture, and Activity, 5* (2), 105-113.

Gadamer, H. G. (1989). *Truth and method*. New York: Continuum Books.

Gordon Calvert, L. (2001). *Mathematical conversations within the practice of mathematics*. New York: Peter Lang.

Grotzer, T.A. (2003). Learning to understand the forms of causality implicit in scientific explanations. *Studies in Science Education, 39,* 1-74.

Johnson, S. (2001). *Emergence: The connected lives of ants, brains, cities, and software.* New York: Scribner

Keil, F.C. & Wilson, R.A. (2000). Explaining Explanation. In F.C. Keil and R.A. Wilson (Eds.), *Explanation and Cognition* (pp.1-18). Cambridge: MIT Press.

Latour, B. (1990). Drawing things together. In M. Lynch and S. Woolgar (Eds.), *Representation in Scientific Practice* (pp.19-68). Cambridge Mass.: MIT Press.

Lemke, J. (1999). Typological and topological meaning in diagnostic discourse. *Discourse Processes, 27*(2), 173-185.

Maturana, H. & Varela, F. (1992). *The Tree of Knowledge: The Biological Roots of Understanding*. Shambala, Boston Massachusetts.

Maturana, H.R. (1988). Reality*: The search for objectivity or the quest for a compelling argument*. The Irish Journal of Psychology: 25-82.

Meyer, K. & Woodruff, E. (1997). Consensually driven explanation in science teaching. *Science Education, 81*, 175-194.

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553-576.

Ogborn, J., Kress, G., Martins, I., & McGillicudy, K. (1996). *Explaining science in the classroom*. Buckingham: Open University Press.

Peirce, C. S. 1957. The logic of abduction. In V. Tomas (Ed.) *Charles S. Peirce: Essays in the Philosophy of Science* (pp. 235-255). New York: Liberal Arts Press.

Popper, K. R. (1983). *Realism and the aim of science.* London: Hutchinson.

Simmt, E. (2000). *Mathematics knowing in action*. Unpublished doctoral dissertation, University of Alberta, Edmonton.

Smith, D.G. (1991). Hermeneutic inquiry: The hermeneutic imagination and the pedagogic text. In E. Short (Ed.), *Forms of curriculum inquiry* (pp. 187-209). New York: SUNY Press.

Tibbets, P. (1990). Representation and the realist-constructivist controversy. In M. Lynch & S. Woolgar (Eds.), *Representation in Scientific Practice* (pp.69-84). Cambridge, Mass.: MIT Press.

Varela, F, Thompson, E., & Rosch, E. (1991). *The embodied mind.* Cambridge: The MIT Press.