Small group argumentation with visual data:

Four modes of negotiating opposition and agreement

(Former subtitle: Negotiating what is seen and what it means)

Josh Radinsky, Susan Goldman, Rachel Doherty & Raedy Ping

Learning Sciences Research Institute

University of Illinois at Chicago

CONTACT EMAIL: joshuar@uic.edu

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Introduction

Our work examines the ways children learn to do science with data visualization tools, specifically geographic information systems (GIS). When a group of middle school students settles in to make sense of such complex visual information for an inquiry project, there are a number of negotiations that occur at different levels. Among other things, they negotiate (1) the task they are being asked to complete – its purpose, meaning, objectives, and procedures (Doyle, 1983; Radinsky, 2000); (2) the role each group member will play, and the norms of interaction they will follow together (Engle, McKinney de Royston & Langer-Osuna, 2007; Radinsky, 2008); and (3) the meanings associated with the data images they see, as symbols for some referents in "represented worlds" (Amaya Becvar, 2005; Parril & Sweetser, 2004), real and/or imagined. These negotiations are often carried out through argumentation, in which students construct opposing positions, and teachers work to shape their discourse to approximate important aspects of the norms of scientific discourse.

We are examining the ways three groups of students constructed opposing positions to one another in the course of a multiple-week earth science inquiry project, focusing on the series of decisions made in the process of creating an "earth science notebook" – an electronic collection of pages meant to represent the key findings of their group, consisting of captured images from the GIS and written and drawn annotations surrounding the images. The present paper describes a case study of the first of these three groups, laying out the analysis that will be conducted for all three cases.

We wanted to know what role argumentative discourse played in the development of particular aspects of scientific reasoning at both the individual and group levels, in the

process of constructing the elements of a "published argument." Teaching practices are backgrounded in this analysis, focusing primarily on the sessions in which the groups worked independently with the GIS, though particular meetings with the teacher are included to highlight learning opportunities.

Research context and methods

This study was conducted in an urban public elementary school, an ethnically and economically diverse magnet school (i.e., drawing students from a range of neighborhoods) that is non-selective in admissions, resulting in academic diversity as well. The school uses a dual-language model of instruction, such that the majority of whole-class instruction is conducted in Spanish, while students' talk in the small groups might vary between languages.

The data were collected in the context of study that took place in two 6th grade classrooms taught by the same teacher during the enactment of the *Earth Structures and Processes* project (Radinsky, Loh, Mundt et al., 1999), a multi-week inquiry unit on plate tectonics using GIS. The unit was part of the regular science curriculum. We followed three groups of three- 6th graders, two in each of the two classrooms. These groups were selected in collaboration with the teacher, with the goal of having diversity in academic performance. We followed these groups over the course of the unit.

The data corpus. The implementation of the unit in the two classrooms was highly similar. In each there were 19 instructional days, each composed of 2 to 4 instructional episodes (e.g., teacher-led instruction, whole class discussion, small-group work, individual student work, student presentations). Each episode was videotaped by one researcher, with another present in the classroom taking field notes. During the small-

group episodes the video camera followed the focal group of three students in each classroom; in all other situations it followed the teacher and/or the flow of whole-class interaction. Of the small-group episodes, we selected four for the present analysis. These four are the complete sample of small group episodes during which students were working with the GIS to assemble a visual and textual explanation of the phenomena they observed – a "*cuaderno"* [science notebook]. This is because we are interested in the processes by which students collectively decided upon how to design these pages of their *cuaderno* as a semi-public "published argument."

We are in the process of completing case studies of the three focal groups, with nested cases of three individuals in each group, identifying argumentative roles and norms, including processes of *positioning* (Engle et al, 2007; Goodwin & Goodwin, 1987; Leander, 2004: Wortham, 2004) of group members that influenced the groups' "published" constructions of meaning of the GIS data images. In this paper we present one of these three groups, to illustrate how we are constructing cases for the larger analysis, and to share the emerging analytical framework that is shaping the analysis. The case study group presented here is referred to as the MGC group, consisting of Maria, Geraldo and Carlos (pseudonyms).

Data collection and analysis

The episodes selected for analysis were those in which students worked in their small groups with the GIS software to conduct a variety of data analysis tasks aimed at understanding and explaining the ways plate motions and tectonic processes might account for phenomena visible in the data. Students used *MyWorld* GIS software (see Radinsky, Alamar et al, 2005 for details), and they used a template designed by the

teacher and researchers in AppleWorks presentation software to assemble their *Cuadernos* documenting their investigation. The template design and rationale were based on prior work of the first author (Loh, Radinsky et al, 2001).

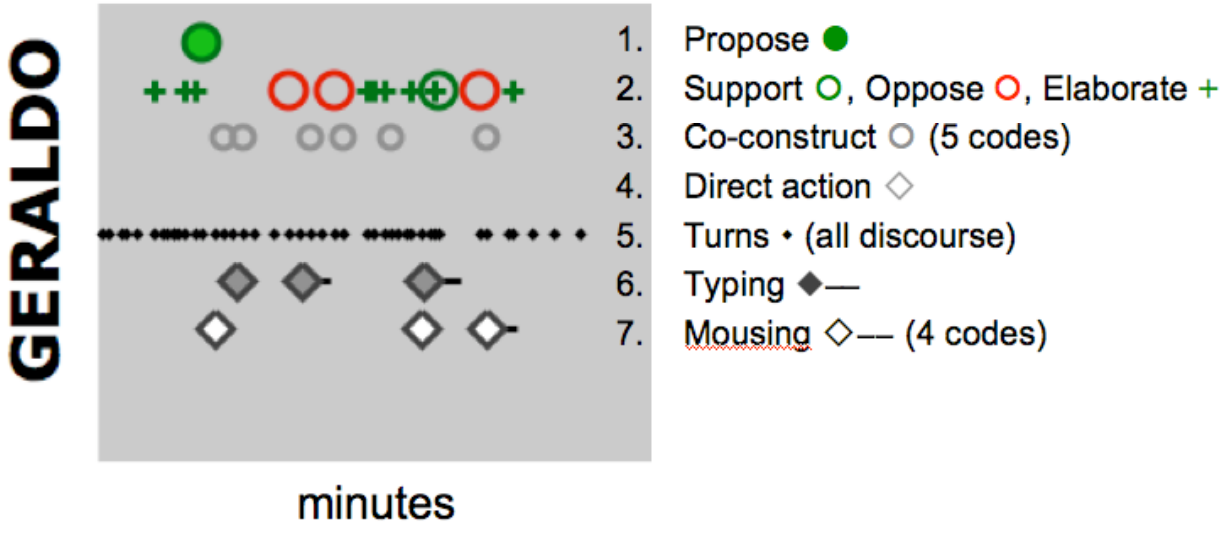
Each of the sessions was videotaped by one researcher, who also took field notes to identify changes in activity structure throughout the lesson. The artifacts of student work were collected each day and archived. The lead researcher worked closely with the teacher, facilitated some lessons, and helped groups of students during the unit.

Case study: Maria, Geraldo and Carlos' (MGC) construction of their *Cuaderno*

This analysis focuses on the work of a group of three students: Maria, Geraldo and Carlos (pseudonyms). The case for this study is constructed on the primary analytical unit of the *published argument* (in this case, the group's *Cuaderno*, a multi-page AppleWorks presentation file), consisting of sub-units of *pages* (five pages in this case), which in turn consist of *page elements* (text typed into three text fields per page; captured image picts pasted into a picture field on each page; and lines, arrows, or other shapes drawn anywhere on the page).

For each *published argument*, the analysis constructs a *process of assembly* conducted by the students over the four instructional days over which students worked on their *Cuadernos*. We assume that key units within the assembly process include *Actions Taken* (AT's) by the group that can be traced to the resulting page elements, and to *Argumentative Discourse Moves* (ADM's) through which the key decisions were made that resulted in the assembled pages in the *Cuaderno.*

ADM's and AT's were coded from the transcripts with reference to the video, and these codes were graphed in a timeline format by minutes, using a musical-staff type notation system. There are seven bars on the transcript "staff":



ADM codes: Verbal discourse categorized as

1. PROPOSE actions ● -- When a possible Action Decision is initiated it is coded as PROPOSE; it may be explicit ("Let's take a picture") or implicit ("Should we take more pictures?"). These are limited to proposed actions that could (or do) shape the assembly of a *cuaderno* page element. These have a special status here, so they are alone on the top bar of the staff – they guide action decisions and shape the flow of argumentative discourse.

2. ARGUMENTATION moves: SUPPORT, OPPOSE, ELABORATE – these are the key moves through which positions of opposition and agreement with proposed or enacted actions are managed:

    a. SUPPORT ○: Agree with an AD, an AT, or a comment/idea

    b. OPPOSE ○: Disagree with or challenge an AD, an AT or a comment/idea

   c. ELABORATE +: Discuss an AD, add a dimension to an AD, re-word an AD, discuss an idea or answer a question

3. CO-CONSTRUCTION moves ○ A variety of moves that mediate the sense that is made of activity or data, usually without explicit argumentative function but contributing to the construction of meaning of the activity (codes collapsed in this category include: verbalize action, request clarification, evaluate actions, ask for evaluation, ask how)

4. DIRECT ACTION ◇ Student tells another student exactly what to do, or gives direction to complete an AT that is on the (discursive/argumentative) floor. These moves are borderline between co-constructing the meaning of activity, and taking action (below), so they have their own bar in the staff, and share a shape with the actions codes, even though they are verbal moves.

5. TURNS ◦ This row shows each turn in group talk: an uninterrupted speech burst with no pause greater than 2 seconds. It gives a sense of overall participation. Everything above this bar is verbal, and everything below is non-verbal.

<u>AT codes: Non-verbal decisions – here, computer actions leading to page elements:</u>

6. TYPING ◆—| continuous turn controlling the keyboard and typing; the line extending to the right shows the duration of the typing move. These moves are non-verbal, and may or may not be accompanied by verbalized co-construction of the decision of what to type.

7. MOUSING ◇—| continuous turn controlling the mouse or touchpad for any computer action other than typing (these actions are not differentiated here); the line extending to the right shows the duration of the time with hand on the mouse

or touchpad (sometimes overlapping when two students both have hands there). These moves are non-verbal, and may or may not be accompanied by verbal characterizations or directions.

These moves were deemed relevant to the analysis because we wanted to trace the genesis of the design decisions that led to the published argument. Our experience told us that some of the important decisions were worked out verbally – a key assumption of the mode of curriculum design and instruction implemented here, in that scientific norms of discourse were meant to develop through these spoken interactions (Radinsky, Alamar & Oliva, 2010) – while others were worked out through the actions taken by group members, with or without verbal accompaniment. For example, it is not uncommon for a group to have an argumentative exchange over a concept, interpretation, or publication decision, and then later for one student to independently (and silently) trump the group's negotiation by typing in words individually.

The full set of each student's AT's and ADM's was graphed in timeline format to identify patterns of participation and argumentation across the four days of work on the *Cuadernos*. In particular, the patterns of PROP moves, and the subsequent support and opposition that emerged for each, were tracked as explanatory narratives for particular elements of the published argument. These same patterns also serve as descriptions of positioning processes that emerged in the group around scientific explanations and group decisions. Similary, the patterns of AT's were used both to characterize interactions that positioned students in particular ways, as well as to explain how particular elements of the published argument emerged.

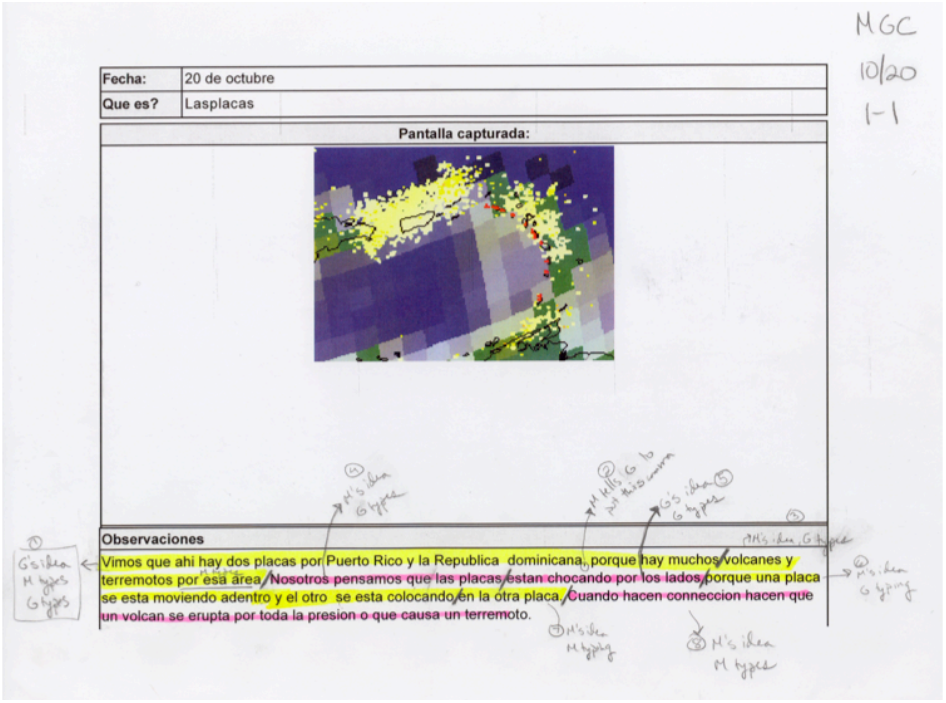
Contents of Cuaderno pages

The first step in the analysis of the *Cuadernos* was the logging of all page elements: pages; textbox contents (3 textboxes per page); and pasted pictures from the GIS, and drawn lines/arrows/shapes accompanying pictures, text, or both. From these page elements, a member of the research team used the transcripts and video tapes to document the genesis of each page and each page element. The content analysis identified particular set of conceptual understandings, drawn from an analysis of interviews presented elsewhere (Goldman et al, 2006), that were evidenced in each page of the MGC notebook.

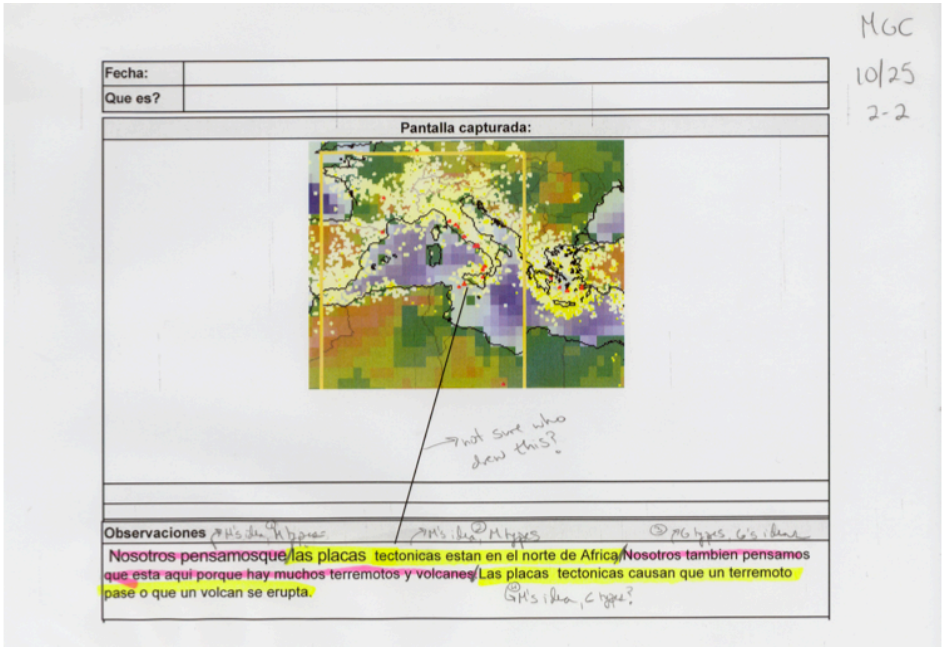
Maria, Geraldo and Carlos' *Cuaderno* included elements that showed substantive engagement with the science content intended for this inquiry project. It evidenced an understanding that the earth's crust consists of plates; that plates move; and that earthquakes and volcanoes are associated with the boundaries of plates. It also showed the group's ability to trace boundary lines from data, as well as a possible confusion between a mass of data at a boundary, and a plate. These understandings are indicated in the summary in Table 1. The five pages of the group's completed *Cuaderno* follow below, including mark-ups referenced in the artifact analysis.

Table 1. Domain concepts, information, and phenomena identified in MGC's pages.

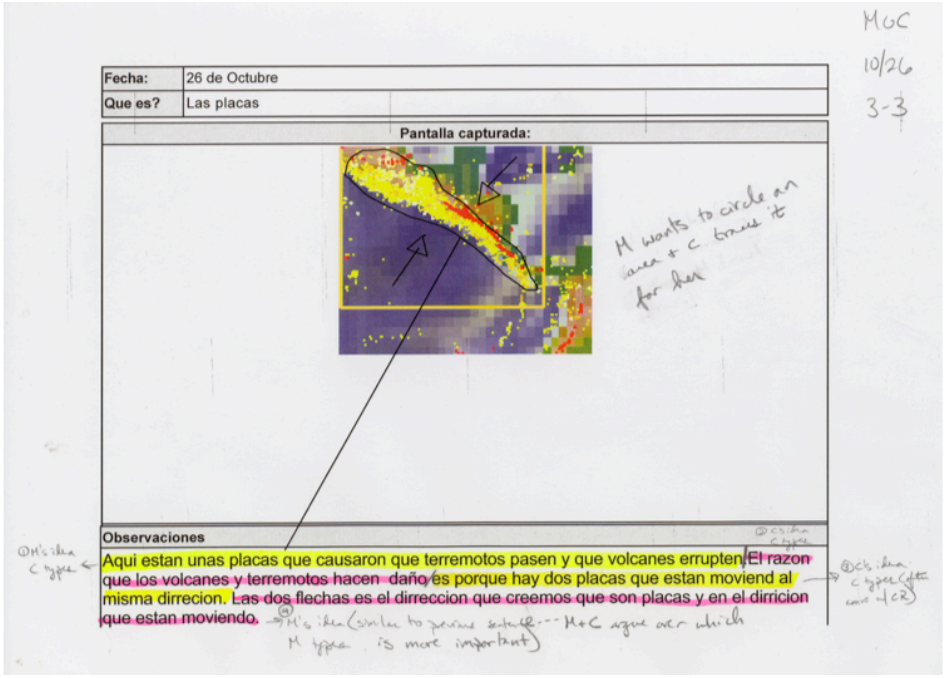
MGC	TOTAL	MGC p1	MGC_p2	MGC_p3	MGC_p4	MGC_p5
Concept Codes						
Volcanoes in named location	0					
Earthquakes in named location	0					
Earthquakes near/in the ocean/below sea leve	0					
Plates meet/connect/make contact	1	x				
Plates move	1			x		
Plates move in named direction	2	x		x		
Plates in named location	2	x	x			
Plates in unnamed location	0					
Plate size	0					
Plates related to volcanoes	2		x	x		
Plates related to earthquakes	2		x	x		
Plate contact causes volcanoes/earthquakes	3	x	x	x		
Plates cause earthquakes	0					
Beginning/end of a plate	0					
Earthquake activity on plates	0					
Number of plates	3	x		x		x
Pattern	1				x	
Pattern of earthquakes	1				x	
Pattern of volcanoes	1				x	
Pattern of Earthquakes related to plates	1				x	
Pattern of Volcanoes related to plates	1				x	
Pattern of Earthquakes and Volcanoes related	0					
Lines						
Lines following volcano pattern	1				x	
Lines following earthquake pattern	1				x	
Lines connect text to map location	3		x	x		x
Line(s) indicate plate location	3		x	x		x
Lines trace plate boundary	0					
Line(s) indicate plate motion / direction	1			x		



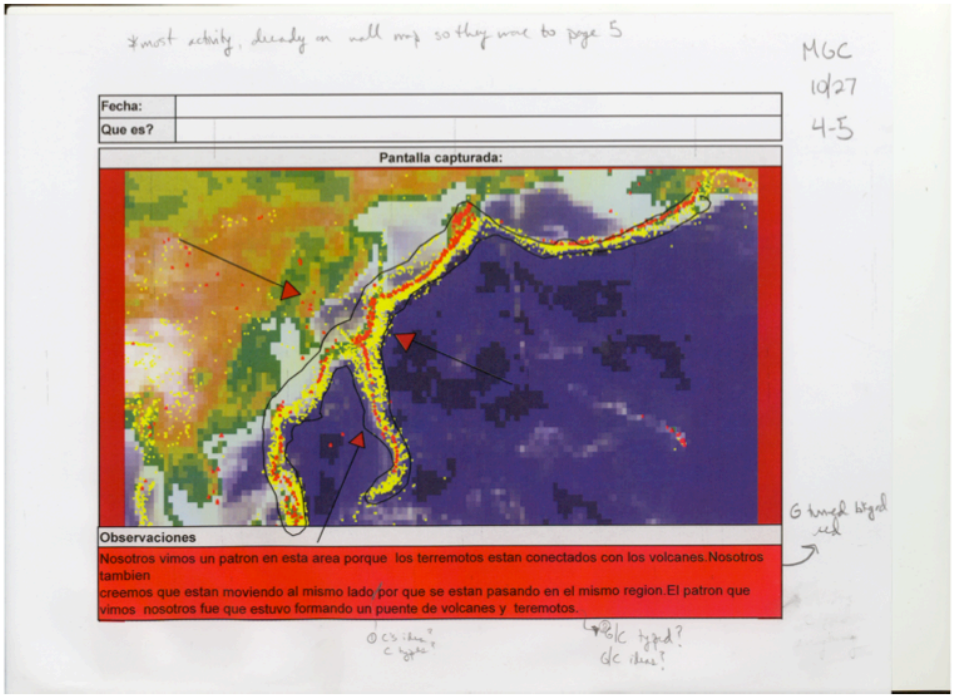
MGC Cuaderno Page 1, completed on Day 1. Captured image of Caribbean containing the Dominican Republic and Puerto Rico, selected by Geraldo, with earthquake (yellow dots), volcano (red dots), elevation (shades of green → brown) and bathymetry (shades of blue) data layers turned on.



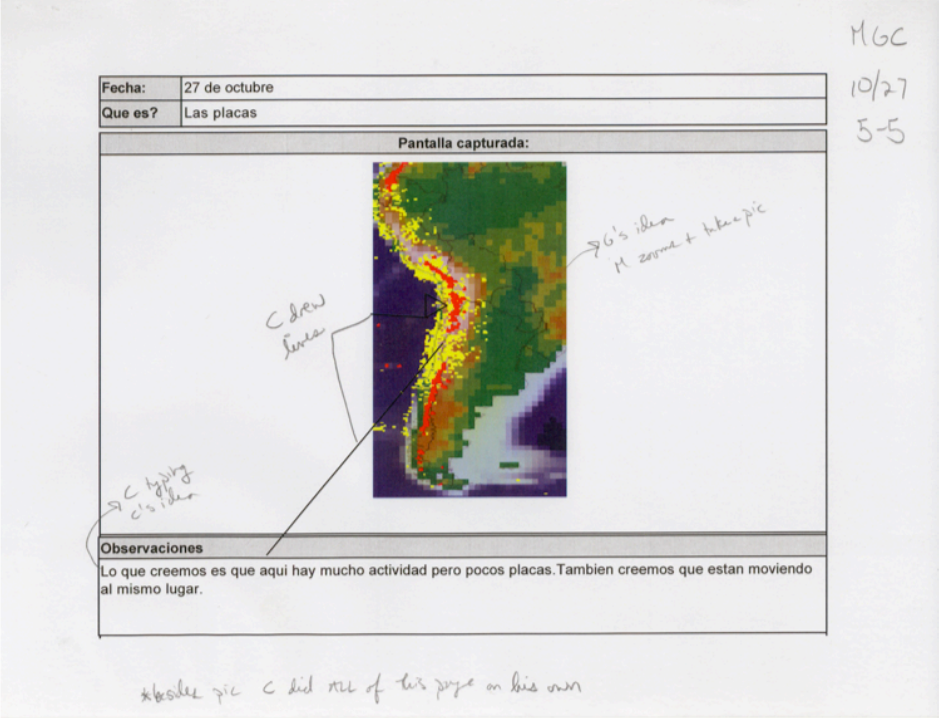
Page 2, completed on Day 2. Captured image of Europe, North Africa and the Mediterranean (referred to as "northern Africa"), with the same data layers. In addition, the yellow box surrounding the area is a map layer highlighting selected "earth structures."



Page 3, completed on Day 3. Image of Central America, with line connecting text to data pattern, and two arrows drawn to convergent show plate motion ("in the same direction").



Page 4, completed on Day 4. Image of east Asia and Pacific. In addition, the yellow box surrounding the area is a map layer highlighting selected "earth structures."



Page 5, completed on Day 4. Image of east southwestern South America, with a line connecting the image to the statement that "here there is much activity but few plates."

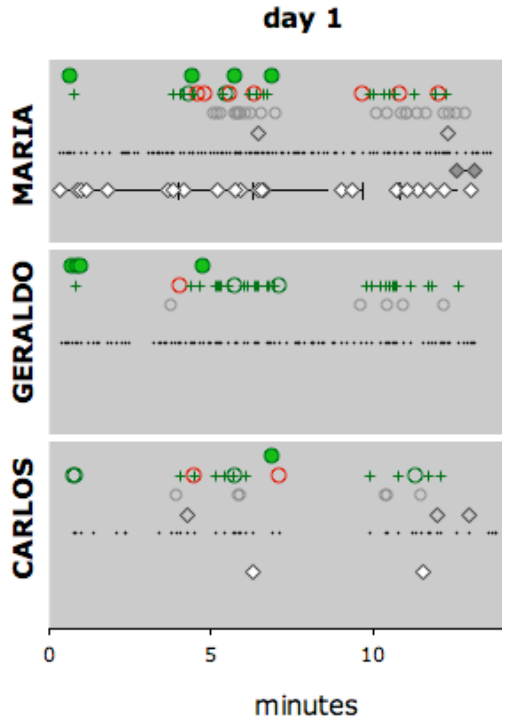
Findings

We identified four modes of argumentation with distinct patterns of discursive moves and actions, and which appear to function in different ways with respect to affording learning through the group inquiry process.

Mode 1: Consensual co-construction

This is a process in which there is give and take among group members in active co-construction of the task, and/or the meanings associated with the data, with general consensus as to key action decisions and little debate. In this mode, PROP moves are well-distributed among group members. There are many SUPP and ELAB moves as the group co-constructs decisions, and OPP moves are generally accepted by group-mates rather than leading to extended disagreements. For the MGC group, this mode was evident on Day 1 and to some extent on Day 4. These segments were preceded in many

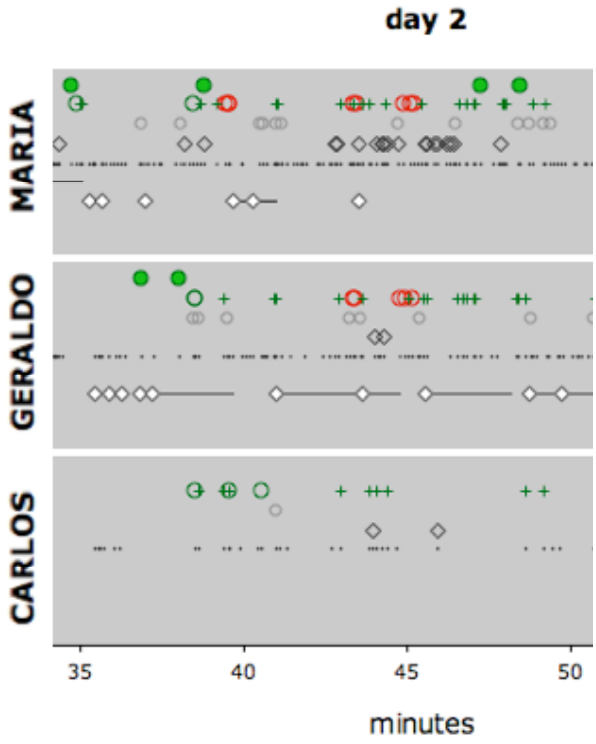
cases by conversations with the teacher that seeded important concepts and pushed for deeper consideration of them. Below is an excerpt of the coded data showing this pattern of argumentation on Day 1:



Mode 2: Struggling together with the task

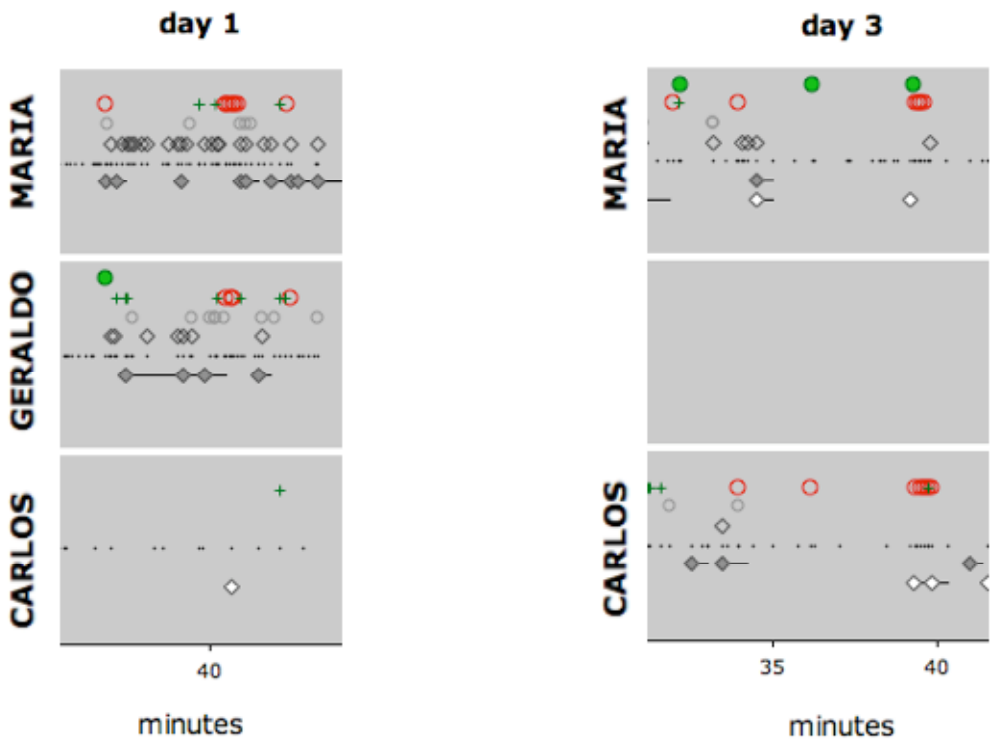
This constitutes a process of figuring out an unfamiliar practice together, which is sometimes conflictual and sometimes more harmonious, but is marked by trying to resolve confusion rather than comfortable co-construction. This mode is marked by fewer PROPs, as students do not know what to suggest in many cases, and lots of elaboration of actions taken, as they experiment with the task. This is not a bad thing; it can be the occasion for growth, as members are practicing the new skills they have been exposed to, and/or the use of unfamiliar concepts (e.g., manipulating the GIS, coordinating the map

with real-world places and data patterns, negotiating with each other). Below is an excerpt of the coded data showing this pattern of argumentation on Day 2:



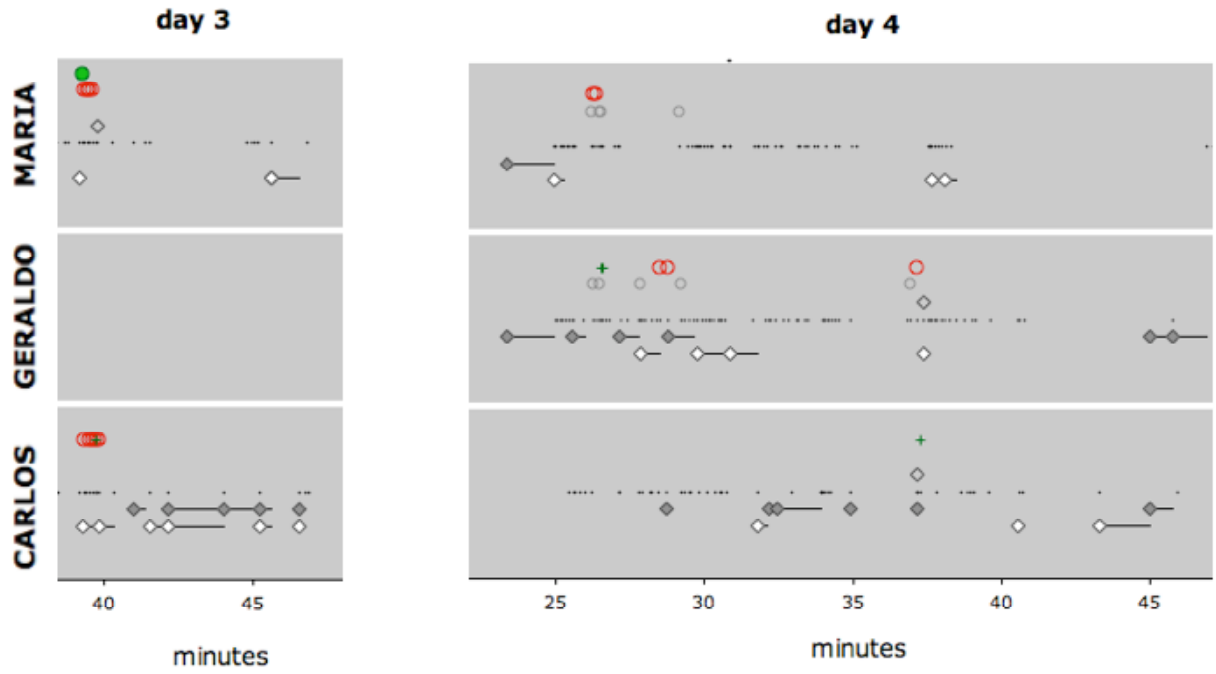
Mode 3: Contentious dispute

Proposing and opposing moves dominate, with little support or elaboration for one another's proposals. Different members believe they know what to do, and that the other is wrong. This can lead to productive debate or to withdrawal from each other. We observed both occurring over the four days of work. Below are excerpts of data showing this mode on Days 1 and 3:



Mode 4: Avoidance of argumentation

In this mode group members withdraw from each other and work separately, avoiding substantive interaction. We saw this in the MGC group, when students' frustration with each other overcame their desire to contribute, and one student was able to take control of the computer while the other(s) gave up. This mode of conflict led to isolated work by one student rather than debate over the science and co-construction of understandings or productive argumentation.



Discussion

Looking across the distributions of these four modes over the four days of work on the *Cuaderno* allows a characterization of the group's dynamics. Most of the decisions in this group were contested, with an ongoing (sometimes playful, sometimes angry) bickering between Maria and Geraldo, which was leveraged at times to address domain content. The contentious mode was driven by Maria, and though Geraldo engaged comfortably in this conflict, it appeared to drive Carlos out of group talk early on in Day 1, and then to drive a wedge between him and Maria on Day 3 when Geraldo was absent. On Day 1 MGC engaged in high levels of consensual co-construction whereas on Day 2 they were mostly struggling together with the task. On Day 3, with Geraldo absent, interactions between Carlos and Maria were contentious and they eventually withdrew from each other and alternated turns at the computer during which they deleted and re-typed each other's words. They avoided argumentation by not interacting over the task.

Day 4 began with efforts at co-construction but was derailed by the teacher's absence and an interruption by an unannounced visitor that took the group off-task.

MGC's *cuaderno* evidenced engagement with many of the key concepts of the *Earth Structures and Processes* unit – evidence of plates and plate boundaries, the understanding that plates move and their motion causes earthquakes and volcanoes, and rather detailed tracing of plate boundaries and viable inferences as to plate motion. Missing from the group's argument is a complete picture of any one plate, or an analysis of how the isolated boundaries identified fit together into larger plate motions. Also missing is an explicit statement of what about the data suggest the directions of plate motion hypothesized.

The episodes of consensual co-construction – especially that on Day 1 – offered this group the opportunity to put some initial examples of data into their *cuaderno* which could serve as a focus for both imaginative pondering by the groups members, and also focused questioning by the teacher during the teacher meeting on Day 1. This mode also marked the main participation of Carlos in the group's process, which produced some of the key ideas which Maria and Geraldo later worked with. Page 1 of the *cuaderno* includes most of the key concepts evidenced in the complete *cuaderno* (see Table 1).

The struggling together mode on Day 2 marked an important and valuable process for this group, but the value of this episode of argumentation is not evident in the published argument. This episode marked the group's attempts and eventual success at mastering several key inquiry skills with GIS – turning on and off data layers strategically, identifying countries on the map, maneuvering around the globe, capturing images and pasting them. It also marked the important argumentative achievement of

coming to a decision on criteria for places "worth capturing" for the *cuaderno* – that is, evidence of tectonic activity, particularly volcanoes. The attempts to locate several specific places on earth, the convergence on a strategy of eliminating places with no "activity," and the trial-and-error practice at manipulating the GIS to produce the desired image, all were carried out through this mode of argumentation. However, these efforts did not result in successful page creation and saving in the *cuaderno* due to a variety of snafus. Had they been successful in saving the 2 to 4 pages they attempted to create, their *cuaderno* would have afforded much more productive reflection as the project concluded.

The disruption of the group's established chemistry on Day 3 (due to Geraldo's absence) appeared to lead gradually to a crisis between Maria and Carlos. Carlos' shy and withdrawn nature provided no buffer for Maria's confrontational stance, and led eventually to the contentious dispute mode that neither could navigate successfully. It is worth noting that other groups in this mode (e.g., CVJ group detailed in Radinsky, 2008; Mario and Joel in Radinsky, Goldman & Singer, 2008) have shown great learning benefit from contentious dispute. However in this case it led not to crystallization of opposing positions to resolve, but rather in withdrawal from verbal argumentation. This mode, for the MGC group, did not further the group's access to the domain. Rather, it led to a dead-end process of typing and re-typing variations on similar claims, with no opportunity to challenge or reinforce these understandings.

The withdrawal mode still appears to be a mode of argumentation, in that conflicting positions were put forward in the written medium. However, this mode did not afford (for this group) a chance to clarify or debate the differences they felt their

positions showed. Instead, some of the key elements of plate motion (e.g., differences among subduction, rift and buckling, and their corresponding data patterns) remained unclear to all three group members, as evidenced in their post interviews.

Rationale for this approach

The approach described here serves as a functional analysis of argumentation. Rather than focus on the structure of specific argumentative moves (claims, warrants, evidence, etc), it attends to the emergent dynamics of argumentation as a discursive genre. This approach gives us a way to understand the processes of positioning that occur in groups in terms of the development of argumentative norms, working backwards from the products of argumentation to the processes that brought them into being.

We see the learning trajectory for argumentative discourse as a developmental process grounded in children's personalities and histories – what Dewey (1933) described as "native resources for reflection." The work of science teaching includes cultivating and constraining these resources to develop students' agency as knowers and doers of science – as participants in scientific argumentation with data.

This study offers a conceptual framework and methodological tools for analyzing interactions between processes of positioning and the development of scientific argumentation, bringing together bodies of research that offer great promise for more robust research on the ways argumentative discourse develops in classrooms.

We are examining the occurrence and distribution of these four modes of argumentation in three other focal groups engaged in the same task. There is evidence of the presence of each mode in each group but the distribution and patterning of them leads to qualitatively different characterizations of the work over the four days. The four modes

help to explain the emergence of different degrees of agency and engagement among the group members with each other and with the science content – differences in how individuals position themselves and are positioned by group members and by their understanding and emerging understanding of the content. We see these modes as providing the core constructs in a framework that can be applied to analyzing interactions between processes of positioning and the development of scientific argumentation and offers great promise for more nuanced understandings of the ways argumentative discourse develops in classrooms.

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