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ABSTRACT

Differences among students can yield rich benefits as well as pose difficult problems during collaborative learning. Students can draw on diverse individual experiences to exchange information, to understand different expressions of shared commonalities, and to construct new possibilities jointly. However, they also face the potential pitfalls of entrenching themselves in opposition to different views, dismissing other perspectives as less important or valid, and misinterpreting others. To examine how individual actions create these benefits and problems, a three-dimensional space is defined, created from the dimensions of evaluation of the previous action (supportive, critical, or unresponsive), problem knowledge content (contribution, repetition, and null), and interactive form (command, question, and statement). Analysis of particular patterns of individual actions indicates how they create beneficial or harmful interactions. Three examples of conversations taking place during collaborative problem solving in an algebra class show how particular individual actions can facilitate or hinder students' collaborative learning. Educators can use a framework developed through this analysis as a collaboration and assessment tool to help students benefit from their individual experiences. (Contains one table, four figures, and eight references.) (Author/SLD)

Building on Diversity:

A moment-to-moment analysis of students collaboratively solving mathematics problems

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Abstract

Differences among students can yield rich benefits as well as pose difficult problems during collaborative learning. Students can draw upon their diverse individual experience to exchange information, to understand the different expressions of their shared commonalities and to jointly construct new possibilities. However, they also face the potential pitfalls of entrenching themselves in opposition to different views, dismissing other perspectives as less important or invalid, and misinterpreting other people.

To examine how individual actions create these benefits and problems, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive) , problem knowledge content (contribution, repetition, and null) , and interactive form (command, question, statement). Analysis of particular patterns of individual actions indicate how they create beneficial or harmful interactions.

Many educational researchers have focused on the needs of diverse students (Rose, 1989; Wong-Fillmore & Meyer, 1992) rather than the potential benefits of student differences. Instead of viewing differences as potential conflicts requiring additional resources, educators can use them as building blocks for learning. This paper examines the learning opportunities that arise from student differences during collaborative problem solving in an algebra class. By analyzing the students' moment-to-moment actions (Sacks, 1974; Schegloff, 1990), we can identify particular individual actions that facilitate (or hinder) students' collaborative learning.

I begin with a general analysis of three examples, showing the benefits and problems that arise from the students' discussion of their different perspectives. Then I consider properties of individuals' actions during these collaborative problem solving segments to create a theoretical framework of individual actions. Using this framework, I then re-analyze the three segments to show how particular individual actions facilitate (or hinder) the collaborative learning process. Finally, I conclude with a summary of the results and implications for educators/teachers and researchers.

BENEFICIAL AND PROBLEMATIC SOCIAL INTERACTIONS

Students can both benefit and suffer from discussing each other's perspectives. Advantages include exchanging information, recognizing shared commonalities, and jointly constructing new possibilities, while disadvantages include entrenched opposition, dismissal, and misinterpretation. Using three segments of student group work, I exemplify each of these advantages and disadvantages.

Potential Advantages

At the simplest level, students with different experiences know different things. As a result, students can benefit from exchanging information with one another. In the following segment, the students debunk each other's stereotypes about the weather in different regions of the United States while adapting the design of a college dormitory to a colder climate. Sitting at a

computer, the students have just calculated the average outside temperature in the new city Duluth, Minnesota and are choosing an appropriate thermostat setting for the dorm rooms.[1]

BE: It's about 45. [Fahrenheit, average Duluth temperature]

MO: Make it at least 19 degrees inside.

TK: I'll make it about 17. [TK as been controlling the computer mouse and enters 17 for the thermostat setting]

BE: It says 45. [looking at Celsius/Fahrenheit conversion chart in a book] The average in San Francisco is about 50

TK: That's about 10 Celsius. [3 second pause] Let's make it 15.

MO: That's too cold.

TK: That's not too cold.

Where did you live before you came here?

MO: Alabama.

TK: No wonder.

MO: It snowed in Alabama.

TK: Oh. [softly]

MO: [3 second pause] 8 inches.

TK: [slaps his hand to his open mouth in mock surprise]

BE: Al-a-bama.

MO: When's the last time it snowed here?

TK: Year before last. [5 second pause] Let's make it 15.

BE: That's 60 degrees!

TK: Uh-huh. [Enters 15 for outside temperature into the computer]

[1]Each transcript is from videotapes of two seventh grade mathematics classrooms in two California urban public high schools. None of the students were friends before this group work, and they were not instructed on group work. They have been working together for over three weeks.

TK argues that MO believes an inside temperature of fifteen degrees Celsius is "too cold" because she's accustomed to the warmer climate of Alabama. When MO asserts "it snowed in Alabama," TK accepts this information with a soft "Oh" and momentary silence. "Oh" used alone with a falling intonation marks recognition or understanding (Schiffrin, 1987), and TK does not contest MO's assertion, suggesting acceptance. Likewise, when MO challenges TK to recall "the last time it snowed here [San Francisco]," TK's response "year before last" draws quiet acceptance from MO who does not contest TK's assertion. In both cases, one student provides new information that the other student accepts.[2]

Students can also learn that their individual experiences are different expressions of a shared commonality. Each individual experience is unique, but others may share facets of that experience. In the following segment, the students use their home experiences to decide how many bathrooms to put into a dormitory suite shared by eight students (same setting as the above segment).

MI: [controls the computer mouse and adds a wall in one bedroom of the dormitory blueprint]

SU: What is the space for?

Why are you putting a wall over there?

MI: It's for an extra bathroom!

SU: You're putting a bathroom over here right?

MI: We having three.

YO: Yeah. This is good. This is good. This is good.

SU: Three?

MI: Yeah.

[2]There are also problems in this interaction that I will address in the section on potential problems during collaboration.

SU: Why do you want three?

MI: Because there are eight people.

SU: So they should have two, one for every four people like in our apartment.

YO: Aren't we going thirteen by thirteen?

MI: I think they should have three bathrooms.

SU: How many people is at your house?

MI: Five.

SU: How many bathrooms are there?

MI: One. [3 second pause] Five one, four one, eight two. [deletes new wall for bathroom]

SU's home contains four people and one bathroom[3] whereas MI's home has five people and one bathroom. Yet, they build a shared sense that there should be two bathrooms for eight people, so MI deletes the wall for the proposed third bathroom. They need not have the exact same people-to-bathrooms ratio (indeed they could be 4:1 vs. 5:1), but their prescriptions sufficiently overlap in this problem to yield a common solution.

Finally, students can build on each other's ideas to jointly construct new alternatives, such as: proposals sparked by a comment, jigsaw pieces, and creative misinterpretations. In the preceding joint constructions, the first speaker contributes progressively more to the resulting proposal. Comments by one person, say a particular word, may spark another person to propose a solution. In addition, both people can put together different parts to create a full solution as jigsaw pieces fit together to complete a puzzle. Finally, one person may creatively misinterpret another person's proposal to construct a better proposal. In the following example, the students build on

[3]MI talked about her home in a later conversation.

each other's ideas to find one component for computing the slope of a pile of beans in a box.[4] Although they have computed the slope of two dimensional objects, such as lines, this is their first attempt to find the slope of a three-dimensional object.

MS: What's the slope?

RA: I don't know.

MS: What IS the slope?

RA: I don't know!

MS: No, I'm thinking. [laughs] I'm just asking myself.

RA: I said I don't know.[dramatic pained expression on face] [4 second pause] I can't even picture this in my mind.[picks up string]

MS: What's across from it? What's going that way? [moves horizontal pen back and forth]

RA: [drops string, picks up ruler and moves it into the box] From where? From the bottom?

MS: Yeah. From the bottom. Tilt it! [lifts a box corner up a bit]

RA: Wait! No! [keeps box down] Because we have to leave it like this. [Places ruler along the bottom of the box at the bean pile corner] It's like seven.

As evidenced by their "I don't know's," these students did not know a method for solving this problem. However, these students built on each other's piecemeal ideas. Responding to RA's comment that she "can't even picture this," MS asks about the horizontal dimension, "What's going that way? [moves horizontal pen back and forth]." Then, RA asks about "the bottom" of the pile, and MS concurs "from the bottom." RA's and MS's comments appear to have sparked

[4]To compute the slope of a bean pile, divide the pile's height by it's radius. In the case of a pile of beans against the corner of a box, the radius is the length from the box corner to the bottom edge of the bean pile.

jigsaw piece ideas that fit together to yield a measurement for the width component of the slope despite MS's misinterpretation of RA's intended measurement method.

Potential problems

In each of these segments, we also see problems that may arise including: entrenched opposition, dismissal, and misinterpretation. When students have invested themselves into particular positions, they may resist all attempts to persuade them. Rather than seeking information and understanding, they may entrench themselves in opposition to other students. This does not occur in any of these three segments, but we see initial steps on the path to entrenched opposition in the first two segments.

MO: that's too cold.

TK: that's not too cold.

SU: So they should have two, one for every four people.

MI: I think they should have three bathrooms.

In both segments, one person states their opposition to the previous speaker's position. At these moments, the collaboration could end with simple rejections of each other's position. In both cases, however, one person explored the other's background experiences to continue the collaboration.

TK: Where did you live before you came here?

SU: How many people is at your house?

Both students asked questions to find information that would support their own positions. Nevertheless they broke the entrenchment by asking about the other person's experience. Moreover, these questions signaled the validity of the other person's experience, building a foundation for a shared understanding.

Understanding another person's reasoning does not necessarily mean acceptance, however. A student can still dismiss it as unimportant or deny its validity entirely. In segment 1, TK acknowledges MO's assertion that "it snowed in Alabama" with an "oh."

TK: that's not too cold.

Where did you live before you came here?

MO: Alabama.

TK: No wonder.

MO: It snowed in Alabama.

TK: Oh. [softly]

However, he still sets the thermostat at fifteen degrees, ignoring MO and BE's protests.

TK: let's make it 15.

BE: that's 60 degrees!

TK: Uh-huh.

[enters 15 for outside temperature into the computer]

In this case, TK accepted the validity of MO's experience, but did not consider it sufficiently important to modify his decision.

Finally, students may misinterpret one another's assertions. To some extent, misinterpretation is unavoidable because people create unique understandings from their individual experiences, and they can not precisely articulate their views. Even when people apparently agree, they may still view the situation differently. In segment three, RA & MS apparently agreed to a particular measurement.

MS: What's across from it?

What's going that way? [moves horizontal pen back and forth]

RA: [drops string, picks up ruler and moves it into the box]

From where?

From the bottom?

MS: Yeah.

From the bottom.

Tilt it! [lifts a box corner a bit]

RA: Wait!

No! [keeps box down]

Because we have to leave it like this.

RA: [Places ruler along the bottom of the box at the bean pile corner] It's like seven.

However, when MS started to help RA measure, their differing perspectives became apparent. This segment also shows the appropriate responses in the face of misinterpretation, elicitation and elaboration. RA asks MS to clarify at the beginning of this segment and RA justifies her action of keeping the box down. (MS affirms at the beginning and her silence at the end suggests acquiescence.)

Individual differences during collaborative learning hold the promise of information exchange, recognition of shared commonalities, and joint construction of new possibilities if participants can successfully negotiate the pitfalls of entrenched opposition, dismissal, and misinterpretation.

INDIVIDUAL ACTIONS

Next, I consider how individual actions facilitate or hinder the negotiation of individual differences during collaborative learning. In this section, I present a framework of individual actions and then apply it to a re-analysis of the earlier three segments.

Each individual action is a sequence of one person's words, motions and/or drawings bracketed by pauses or falling intonations, e.g.: "what do we do next?" [shrugs his shoulders], and [writes "3 x 5 = 15" on the assignment sheet]. Between the actions of other people, a person may

perform one or more consecutive actions (a turn). Simultaneous actions (e.g. an utterance with a gesture) are identified separately, but are treated as one action in the analysis.

Interactive properties of individual actions

In the earlier discussions of each segment, contributions of new information, evaluations in the form of acceptance or criticism, and questions seemed to play important roles. Consider a brief exchange from the last segment:

RA: From the bottom?

MS: Yeah.

From the bottom.

RA's action is simultaneously a contribution of new information and a question inviting an evaluation. In contrast, MS's action does not contribute new information to the problem solution, is a statement, and also accepts the previous idea. Her second action is also a statement that supports the previous action and repeats all of RA's utterance.

Rather than simply listing different types of individual actions, I examine their interactive properties and the dimensions along which they lie. Using the above contrasts to form dimensions, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive), problem knowledge content (contribution, repetition, and null), and interactive form (command, question, statement). See figure 1.

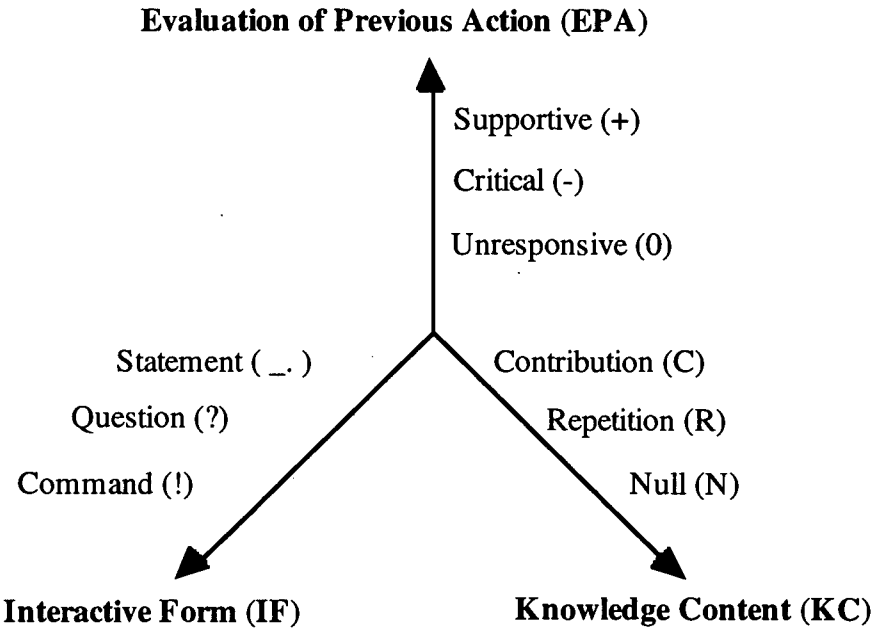

Figure 1. The dimensions and their properties that form the space in which I locate individual actions.

Evaluation of the previous action (EPA)

The evaluation of the previous action dimension characterizes how the current speaker assesses the previous action. After a person proposes an idea (e.g. "two hours times six miles per hour is ten"), one can support it entirely (+), reject at least part of it (-), or ignore it (0). (See figure 2.) Supportive actions (+) reinforce the direction of the current problem solving approach through acknowledgments ("yep"), justifications ("cause it only moves for two of the four hours"), criticism of alternatives ("times four hours assumes it's always moving"), etc. Finally, they encourage friendly social relationships through promoting positive social face (Brown & Levinson, 1987), especially if the participants invest themselves in their ideas.

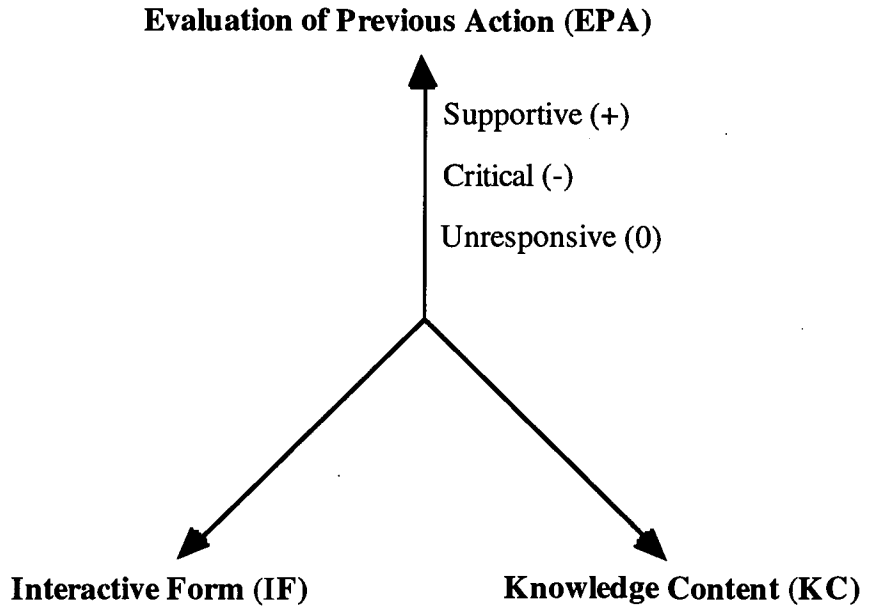

Figure 2. The evaluation of previous action dimension captures how the current action evaluates the previous action, supportively, critically, or unresponsively.

Criticism (-) includes both partial and total rejection. Partial rejection accepts the general framing of the proposal but notes errors ("twelve, not ten"), suggests related alternatives ("how about four hours times six?") or challenges some parts ("why two hours?"). In contrast, total rejection denies the validity of the whole frame of the proposal ("we have to find the acceleration, not the distance"). Since the distinction between partial and total rejection is difficult to delineate, I have chosen to group them together. Criticisms alter the problem solving trajectory by identifying flaws and opening alternatives. As before, if the previous speaker identifies his ideas with himself, cognitive rejection of the idea may also threaten psychological rejection of the person (especially without accompanying face-saving measures [Brown & Levinson, 1987]).

Finally, unresponsive actions (0) do not evaluate the previous action at all, initiating new topics instead ("is this on the quiz?").[5] Unresponsive actions draw the conversation away from

[5]One possible distortion may arise from a person presenting a series of proposals one after another in one turn. This analysis assumes that the speaker only evaluates the last action. If the person responds to any proposal except the last one, that act is coded as unresponsive (0). This is an issue for conversations in which people lay out a series of alternatives, for example in structured, management decision-making.

the previous speaker's solution approach entirely and pose a greater threat to the social relationship. They may present the worst threat to social face by ignoring the previous speaker's action, judging it as unworthy of comment. So, participants who initiate more new topics (through unresponsive actions) to which others respond show greater authority and control.

Knowledge content (KC)

The knowledge content dimension characterizes the problem knowledge displayed during the interaction and forms a continuum that includes non-overlapping contributions, overlapping contributions, synonymous repetitions, partial repetitions, exact repetitions, and null actions. (See figure 3.)

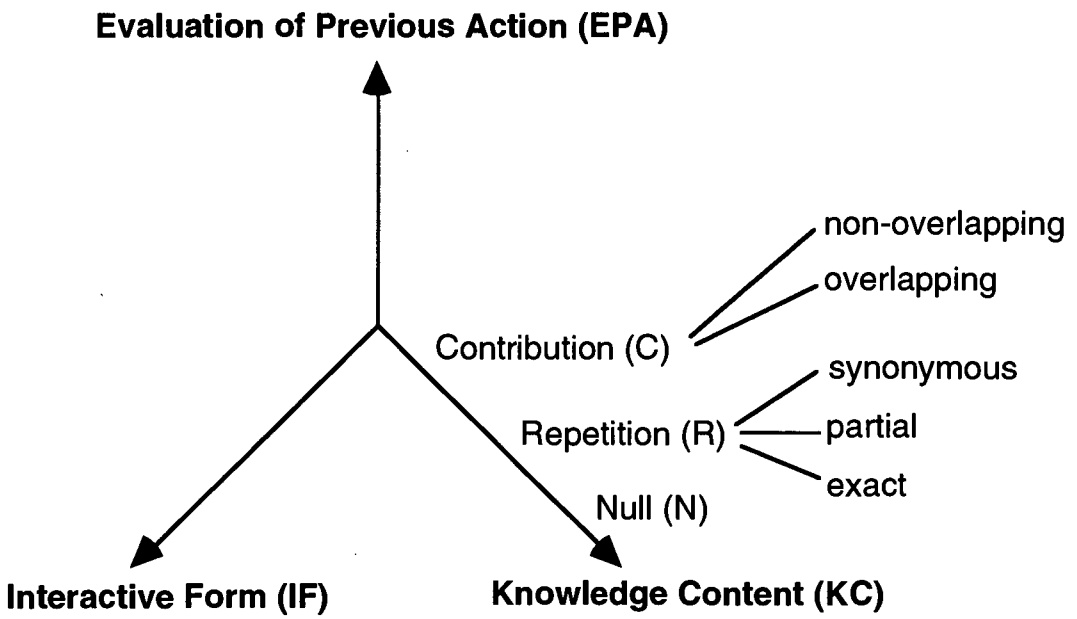

Figure 3. The knowledge content dimension describes the action with respect to a problem solution and to the knowledge content of previous actions. Contributions provide new information related to a solution and may overlap with an earlier contribution. Repetitions repeat an earlier contribution's ideas with synonyms or its words (either partially or exactly). Finally, null actions do not provide information related to a solution.

Consider each type of knowledge content in response to the phrase "two hours times six miles per hour." A non-overlapping contribution provides problem information without repeating any part of any previous action, e.g. "that'll give us the distance." In contrast, an overlapping contribution adds new information in combination with information from a previous action, "so the train moves twelve miles in two hours." In general, contributions (C) are new problem solving ideas or actions introduced into the collaboration and indicate moments of potential progress in the problem solving. Contributions include new goals, proposals, justifications, consequences, critiques, alternatives, and summaries. Tracing the contributions provides a map of the group's problem solving route. Meanwhile, repetitions (R) repeat the knowledge content of previous actions (not necessarily the immediately preceding one). Synonymous repetitions elaborate previous actions, but do not add significant new information, "two hours multiplied by six miles per hour." Meanwhile, partial and exact repetitions repeat part or all of a previous action precisely, "two times six" (partial)[6] and "two hours times six miles per hour" (exact). Repetitions can indicate the speaker's level of understanding and degree of agreement with previous contributions. Finally, null actions do not contribute specific, new problem-related information and do not repeat old information, "yeah." (Null actions can be repeated, but I always classify them as null actions, never repetitions.)[7] Since null actions are typically brief, they can provide feedback without interrupting the current speaker (backchannel responses).

Interactive form (IF)

The interactive form dimension describes the different degrees of encouragement for audience participation and includes at least three possibilities: statements, questions, and commands. See figure 4.

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[6]Partial repetitions must maintain the same meaning of the previous action, so negations by omission are contributions. "These birds can fly for two miles non-stop" is a contribution, not a repetition of "none of these birds can fly for two miles non-stop."

[7]Note that actions in off-task conversations are not labeled contributions. Instead, they are labeled as null content actions because they do not contribute to the problem solution.

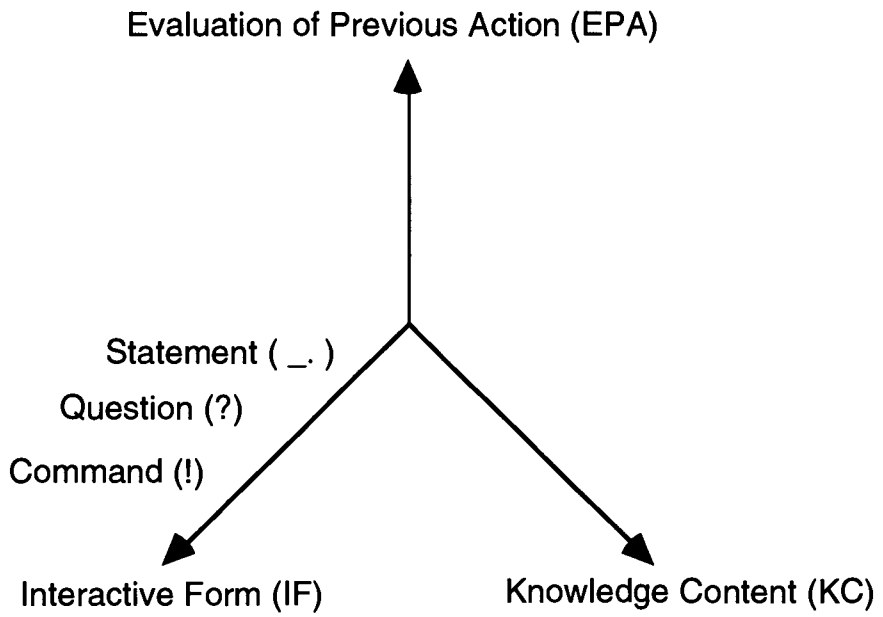

Figure 4. The interactive form dimension characterizes the degree in which a particular action invites participation from the audience. Statements, questions, and commands invite progressively more participation.

Statements (_.) declare information unintrusively, without eliciting participation from others. Virtually all the sentences in this paper are statements in which a subject precedes a predicate, e.g. "five times seven is thirty-four." In contrast, questions (?) invite audience participation intrusively by articulating an action/information gap for them to fill, thereby requesting an action. Typical questions end with rising intonations, e.g. "what's two times six?" Finally, commands (!) demand obedient audience participation without asking for their evaluation. Typical commands begin with verbs, "multiply two times six!"

The degree of interaction that these three forms initiate also vary within each form as well. The following types of statements elicit different degrees of participation: definitive vs. uncertain, summary vs. goal, and directives. Definitive statements discourage further discussion of what the speaker perceives to be a known truth ("two times six is twelve") while uncertain statements

encourage input on the validity of the statement ("two times six seems like twelve"). Likewise, summary statements tend to close interactions by articulating what the group has already accepted ("so we got twelve miles by multiplying two hours and six miles per hour") whereas goal statements encourage interaction by presenting a target towards which the group can work ("we need to find the distance"). Finally, directive statements present information that implies a directive toward action (Searle, 1969). The directive "two times six can't be ten" suggests that the audience recalculate the product of two and six. In short, definitive summaries, definitive goals, uncertain summaries, uncertain goals, and directives are all statements, but encourage successively greater participation.

Rhetorical, tag, choice, and open questions also initiate different degrees of interaction. Although the form of a rhetorical question invites responses ("can't you do anything right?"), the speaker knows the answer and does not expect a response. Tag questions follow statements and anticipate simple acknowledgments, "two times six is twelve, right?" Meanwhile, choice questions offer multiple possibilities from which the audience can select, "should we add or multiply?" Finally, speakers asking open questions do not restrict the answers and invite a greater variety of responses, "what should we do next?" Rhetorical, tag, choice, and open questions invite successively greater participation.

Finally, commands can also elicit different degrees of interaction. Although most commands demand audience action, blocking commands demand audience inaction, e.g. "wait!" Detailed commands specify particular actions, "measure the length of the box." Finally, open commands request general input from the audience, "give me your opinion." Blocking, detailed, and open commands demand increasingly greater audience participation.

The three major categories of interactive forms (statements, questions, and commands) generally encourage different degrees of audience participation, but they also vary within each

category. Future analyses may incorporate finer distinctions, but this paper only uses the major categories within each interactive dimension of analysis to define individual actions.

Types of Individual Actions

This section describes twenty-seven individual actions and their locations within the space created by the three dimensions of evaluation of previous action, knowledge content, and interactive form (see Table 1).

Table 1. Individual actions organized along three dimensions, evaluation of the previous action, problem knowledge content, and interactive form

Evaluation of Previous Action	Knowledge Content	Interactive Form		
		Statement (_.)	Question (?)	Command (!)
Unresponsive (0)	Contribution (C)	Announcement (0C_.)	Proposal (0C?)	Sudden order (0C!)
	Repetition (R)	Fixation (0R_.)	Echo request (0R?)	Echo command (0R!)
	Null (N)	External action (0N_.)	General request (0N?)	Starter (0N!)
Supportive (+)	Contribution (C)	Supportive addition (+C_.)	Supportive proposal (+C?)	Implementation command (+C!)
	Repetition (R)	Verification (+R_.)	Check of others (+R?)	Repeat commands (+R!)
	Null (N)	Acknowledgment (+N_.)	Supportive request (+N?)	Execution command (+N!)
Critical (-)	Contribution (C)	Critical addition (-C_.)	Counter-proposal (-C?)	Counter-order (-C!)
	Repetition (R)	Repeat Critique (-R_.)	Exact challenge (-R?)	Repeat counter-order (-R!)
	Null (N)	Denial (-N_.)	General challenge (-N?)	Halt (-N!)

I will begin with individual actions that ignore the previous action (0) and contribute new ideas (C): announcements, proposals, and sudden orders. Speakers using these actions attempt to close off the previous discussion/series of actions (if there were any) and/or initiate new (possibly parallel) conversations. As discussed earlier, unresponsive actions (0) can rupture the social fabric by rejecting the previous action (if any) as unworthy of comment. Announcements (0C_.) are statements that initiate a topic of discussion ("we have to find the distance") or that occur during brainstorming ("we can try graphing it"). Proposals (0C?) serve the same purpose, but also elicit evaluations from others ("are we finding the distance?"). Finally, sudden orders (0C!) demand implementation from the audience without requesting an evaluation ("find the distance" and "multiply two times six").

Now consider unresponsive actions (0) and repetitions (R): fixations, echo requests, and echo orders. By using these actions, the speaker reconsiders an earlier rejected or ignored idea without regard to the current conversation. Fixations (0R_.) indicate construction of new understanding of the old idea ("distance is rate times time!") or an attempt to do so ("rate times time ...") without intruding upon others. In contrast, echo requests (0R?) encourage others to consider a past idea ("rate times time equals distance?") while echo commands (0R!) demand that the audience act on a past idea ("multiply the rate and time again!").

The last set of unresponsive actions (0) are null actions (N) that ignore the previous action but do not specify another direction for the conversation: external actions, general requests, and starters. External actions (0N_.) indicate that the speaker is attending to something other than the problem solving activity ([looking out the window] or singing a tune "skiddly dee dop, da dee dop, da dee dop"). Meanwhile, general requests (0N?) invite others to participate in a new series of actions ("what are we supposed to do?") or to summarize ("what did we do?"). Finally, starters (0N!) initiate activities without specific instructions ("get to it!").

In short, people can ignore the previous action by contributing new ideas (announcements, proposals, and sudden orders), repeating past actions (fixations, echo requests, and echo orders), and performing null actions (distractions, general requests, and starters).

Next, I specify supportive evaluations (+), beginning with contributions (C): supportive additions, supportive proposals, and implementation commands. This set of actions justifies the previous action, articulates additional beneficial consequences and/or continues with an appropriate action. Supportive additions (+C_.) indicate that the speaker understands and accepts the previous action according to his/her own interpretation ("that gives us the distance"). Speakers may choose supportive proposals (+C?) that suggest less certainty to test their ideas or to test the other group members' understanding ("so that gives us the distance?"). Finally, speakers use implementation commands (+C!) to order others to perform consequent actions ("so multiply two and six").

People can support the previous action (+) by using repetitions (R) that indicate their understanding: verifications, checks of others, and repeat commands. Verifications (+R_.) may confirm understanding of the previous action ("twelve"), indicate that the speaker is trying to make sense of it ("times two ... is ... twelve"), or repeat the previous action to check its validity ([presses the following calculator keys: 2, x, 6, =] "twelve!"). To test whether the other group members understand the previous action, a person may use checks of others (+R?), typically through synonymous or partial repetitions ("hours times miles per hour is miles?"). People use repeat commands (+R!) to pass along the instruction to another person ("José, multiply two by six"), to repeat an ignored command ("I said multiply two by six"), or to repeat an incorrectly implemented command ("multiply two by SIX").

People can also support previous actions (+) through null actions (N): acknowledgments, supportive requests, and executions. By using an acknowledgment (+N_.), a person can indicate acceptance of the current speaker's idea without interrupting (backchannel feedback, e.g. "uh-huh" and [nods]). Supportive requests (+N?) include continuation requests and tag questions.

Continuation requests are open questions that ask for the next step in the solution, ("what's next?") while tag questions ask for confirmation of the previous action ("right?" expects a "yes" or "no" response). Finally, execution commands (+N!) affirm previous proposals (C?) and demand that others to act upon them ("do it").

In short, people can support the previous action by contributing new ideas (supportive additions, supportive proposals, and implementation commands), repeating past actions (verifications, checks of others, and repeat commands), and performing null actions (acknowledgments, supportive requests, and executions).

Finally, consider critical evaluations (-), beginning with contributions (C): critical additions, counter-proposals, and counter-orders. Critical contributions present new ideas that reject at least part of the previous action by providing an alternative, revealing a flaw in the reasoning, or showing an undesirable consequence. When using a critical addition (-C_.), a person objects to the previous action by presenting an alternative ("two PLUS six"), a revealed flaw ("the train only goes four hours"), or an unwanted consequence ("but by then the train has passed the car"). Counter proposals (-C?) soften critical suggestions by inviting others to evaluate the criticism ("shouldn't we multiply by two since the car only goes for two hours?"). As discussed earlier, the question form may also indicate low confidence in the suggestion ("should we multiply by two ..."). In contrast, a counter-order (-C!) not only criticizes the previous action but expects the audience to act immediately on a new order ("do two times six instead of four times six").

People can also criticize (-) through repetitions (R): repeat critique, exact challenge, and repeat counter-order. Repeat critiques (-R_.) reject the previous action by repeating an earlier action ("it's only going four hours") or by noting the violation of an earlier premise ("you said that it was only going four hours"). This tactic should be extremely persuasive if the audience had agreed upon the earlier premise. Exact challenges (-R?) soften premise violations ("didn't you say that it was only going for two hours?") or question the validity of the previous action by requesting

clarification ("it's going for two hours?") If a person issues a repeat counter-order (-R!), he/she has repeated an order over someone's criticism ("do two times six anyway!").

People also criticize (-) through null actions (N): denials, general challenges, and halts. Denials (-N_.), the mirror images of acknowledgments, provide negative backchannel feedback ("uh-uh" and [shakes her head]). Unlike exact challenges, general challenges (-N?) do not specify the area of concern ("why?"). Finally, people use halts (-N!) to prevent someone from performing an action ("stop!").

In short, people can criticize the previous action by contributing new ideas (critical additions, counter-proposals, and counter-orders), repeating past actions (repeat critique, exact challenge, and repeat counter-order), and performing null actions (denials, general challenges, and halts).

IMPACT OF INDIVIDUAL ACTIONS

Let us reconsider our earlier segments using the above framework to examine how patterns of individual actions may create beneficial or harmful situations.

Re-analysis of the first segment

In the re-analysis of the first segment, we can identify specific types of actions that account for the avoidance of entrenched opposition, the exchange of information, and the dismissal of different perspectives

EPA	KC	IF		
+	C	_.	BE:	it's about 45. [Fahrenheit, average Duluth temperature]
0	C	!	MO:	make it at least 19 degrees inside.
-	C	_.	TK:	I'll make it about 17.

+	C	_.		[has been controlling the computer mouse and enters 17 for the thermostat setting/inside temperature]
0	C	_.	BE:	it says 45. [looking at Celsius/Fahrenheit conversion chart in a book]
0	C	_.		the average in San Francisco is about 50
+	C	_.	TK:	that's about 10 Celsius
				[3 second pause]
0	C	!		let's make it 15
-	C	_.	MO:	that's too cold.
-	C	_.	TK:	that's not too cold.
+	C	?		Where did you live before you came here?
+	C	_.	MO:	Alabama.
+	N	_.	TK:	No wonder.
-	C	_.	MO:	It snowed in Alabama.
+	N	_.	TK:	Oh. [softly]
				[3 second pause]
+	C	_.	MO:	8 inches.
-	N	_.	TK:	[slaps his hand to his open mouth in mock surprise]
0	N	_.	BE:	Al-a-bama.
-*	C	?	MO:	When's the last time it snowed here?
-	C	_.	TK:	year before last.
				[5 second pause]
0	R	!		let's make it 15.
-	C	_.	BE:	that's 60 degrees!

+	N	_.	TK:	Uh-huh.
0	C	_.		[enters 15 for outside temperature into the computer]

* MO ignores BE's action and responds to TK's last action.

After BE computes the average outside temperature, MO initiates a new topic with a command (0C!) to set the thermostat at nineteen degrees. However, TK rejects it with an alternative (-C_.) After a few unresponsive turns, TK suddenly orders (0C!) implementation of a more extreme suggestion of fifteen degrees that MO critiques (-C_.). When TK rejects MO's criticism (-C_.), the students have an opportunity for rigidly holding their positions in entrenched opposition. Instead of simply holding his position through denials (-N_.) and repeat critiques (-R_.), TK asks MO to contribute information with a question (+C?). In general, eliciting information from others through questions (?) can provide a way out of fixed opposition. Moreover, questions are a standard linguistic tool for eliciting information. TK invites MO to talk about her previous experience with the weather to set up a criticism based on common ground. When MO answers (+C_.), TK accepts (+N_.) her information triumphantly. TK's supportive evaluation (+) of MO's assertion through his acknowledgment (+N_.) provides evidence that he accepts MO's information which otherwise can be contested. Students can also provide unsolicited information (C without an immediately preceding ?) as indicated in the next action. MO critiques TK's reasoning (-C_.) with a follow-up comment on the snow in Alabama. With considerably less enthusiasm, TK also acknowledges this information (+N_.). When MO further emphasizes this point with a supportive addition (+C_.) however, TK disparages (-N_.) her contribution, perhaps resenting her continued emphasis on this point. After BE's external action (0N_.), MO solicits information through a counter-proposal (-C?), challenging TK by asking him about his climate. TK's response (-C_.) draws silence and acceptance from MO. Despite apparently accepting MO's information, TK dismisses MO's different perspective and re-issues his echo command (0R!) of fifteen degrees. Furthermore, TK acknowledges (+N_.) BE's critique (-C_.), but proceeds to implement (0C_.) his

decision. In general, unresponsive actions (0) following another person's criticism (-) or unresponsive action (0) in the previous turn typically indicates dismissal of the other person's perspective.

In short, questions (?) provide a way out of entrenched opposition and elicit information (C) from others. However, the listener must accept the information, typically indicated by a supportive evaluation (+). Finally, critical (-) or unresponsive actions (0) in the previous turn followed by unresponsive evaluations (0) typically indicate dismissals of differing perspectives.

Re-analysis of the second segment

In the re-analysis of the second segment, we can identify specific types of actions that can initiate entrenched opposition and build shared commonalities.

EPA	KC	IF		
0	C	_.	MI:	[controls the computer mouse and adds a wall in one bedroom of the dormitory blueprint]
-	C	?	SU:	What is the space for?
+	C	?		Why are you putting a wall over there?
-	C	_.	MI:	It's for an extra bathroom!
-	C	?	SU:	You're putting a bathroom over here right?
-	C	_.	MI:	We having three.
+	N	_.	YO:	Yeah.
+	N	_.		This is good.
+	N	_.		This is good.
+	N	_.		This is good.
-	R	?	SU:	Three?
-	N	_.	MI:	Yeah.

-	R	?	SU:	Why do you want three?
-	C	_.	MI:	Because there are eight people.
-	C	_.	SU:	So they should have two,
+	C	_.		one for every four people like in our apartment
0	C	?	YO:	Aren't we going thirteen by thirteen?
-*	R	_.	MI:	I think they should have three bathrooms.
0	C	?	SU:	How many people is at your house?
+	C	_.	MI:	Five.
0	C	?	SU:	How many bathrooms are there?
+	C	_.	MI:	One.
				[3 second pause]
+	R	_.	MI:	Five one,
+	R	_.		Four one,
+	C	_.		Eight two.
+	C	_.		[deletes new wall for bathroom]

* MI criticizes SU's action, ignoring YO's recent comment.

At the beginning of this segment, MI unilaterally adds a wall to the floor plan to create an additional bathroom (0C_.). After MI explains this (C) in response to SU's questions (?), they argue over the desirability of three bathrooms. YO supports the current design (+N_.), but does not engage in the discussion. Although MI invites entrenched opposition through her denial (-N_.) and her repeat critique (-R_.), SU's questions (?) elicit MI's continued engagement in the discussion. MI responds to SU's exact challenge (-R?) by referring to the eight residents (-C_.), but SU critiques (-C_.) this reference by offering a specific ratio from her own home. Ignoring YO's unresponsive proposal (0C?), MI repeats her opposition (-R_.). SU tries another line of questions (?), this time asking MI about her experiences with people and bathrooms in her home.

After summarizing the ratios of SU's and her own different experiences through supportive repetitions (+R), she creates (+C) a shared conclusion ("eight two").

In short, denials (-N_.) and repeat critiques (-R_.) threaten to solidify opposition, but questions (?) elicit continued engagement and provide a way out of gridlock. Moreover, supportive repetitions (+R) of different perspectives (-C) followed by supportive contributions (+C) typically indicate the recognition of shared commonalities in the midst of different individual experiences.

Re-analysis of the third segment

In the re-analysis of the third segment, we can identify specific types of actions that can contribute to joint construction and indicate misinterpretation.

EPA	KC	IF		Actions
0	C	?	MS:	What's the slope?
+	N	_.	RA:	I don't know.
0	R	?	MS:	What IS the slope?
+	N	_.	RA:	I don't know!
-	N	_.	MS:	No,
+	N	_.		I'm thinking. [laughs]
+	N	_.		I'm just asking myself.
-	N	_.	RA:	I said I don't know.[dramatic pained expression on face]
0	C	_.		(4 second pause) I can't even picture this in my mind.[picks up string]
+	C	?	MS:	What's across from it?
+	C	?		What's going that way? [moves horizontal pen back and forth]

+	C	_.	RA:	[drops string, picks up ruler and moves it into the box]
+	C	?		From where?
+	C	?		From the bottom?
+	N	_.	MS:	Yeah.
+	R	_.		From the bottom.
+	C	!		Tilt it! [lifts a box corner up a bit]
-	N	!	RA:	Wait!
+	N	!		No!
+	C	_.		[keeps box down]
+	C	_.		Because we have to leave it like this.
+	C	_.	RA:	[Places ruler along the bottom of the box at the bean pile corner] It's like seven.

The short turns, absence of commands (!), and early null actions (N) suggested MS and RA's lack of a solution method. However, they begin building on each other's actions with supportive contributions (+C). MS also indicated her understanding through verifications (+R_.), and they elicited evaluations of their ideas through supportive proposals (+C?). This piece by piece joint construction contributes to the solution in this segment and eventually creates a correct solution in the following fifteen minutes. In general, joint construction occurs when students are cooperating, building on each other's ideas to create a new understanding that none of them could articulate before the interaction. The students cooperate with one another through evaluative contributions (+C and -C) and repetitions (R) in the form of questions (?) and statements (_.). Near the end of this segment, the string of supportive contributions (+C) suddenly ends with a halt (-N!), indicating a misinterpretation that RA corrects and explains with supportive additions (+C_.). Misinterpretations probably occur throughout the interaction because participants draw upon their individual experiences to construct unique understandings. Nevertheless, the overlaps in these

understandings may suffice for their immediate goals. However, misinterpretations arising from different perspectives stand out when a critical action (-) follows a long string of mutually supportive actions (+) among different speakers. Possible remedies for unclear interpretations include requests for clarification (+N?, -R?, and -N?) and elaboration of one's own views (+C). In this segment, MS and RA generally elaborated their own ideas.

In short, strings of evaluative contributions (+C and -C) and repetitions in the form of questions (?) and statements (_.) indicate joint construction while long strings of supportive actions (+) among different speakers followed by a critical action (-) typically indicates a recognized misinterpretation.

CONCLUSION

In this section, I briefly summarize the results at the segment and individual action levels before discussing the educational and research implications.

Differences among students can yield rich benefits as well as pose difficult problems during collaborative learning. Students can draw upon their diverse individual experience to exchange information, to understand the different expressions of their shared commonalities and to jointly construct new possibilities. However, they also face the potential pitfalls of entrenching themselves in opposition to different views, dismissing other perspectives as less important or invalid, and misinterpreting other people.

To examine how individual actions create these benefits and problems, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive), problem knowledge content (contribution, repetition, and null), and interactive form (command, question, statement). Particular patterns of individual actions indicate how students use their differences beneficially to exchange information, recognize shared commonalities, and jointly construct new possibilities as well as destructively to entrench themselves in opposition, dismiss other perspectives, and misinterpret other people. Questions

elicit information that are subsequently supported, typically through acknowledgments. Moreover, supportive repetitions of different perspectives followed by supportive contributions typically indicate the recognition of shared commonalities in the midst of different individual experiences. Meanwhile, strings of evaluative contributions and repetitions in the form of questions and statements create joint constructions. On the other hand, denials and repeat critiques threaten to entrench opposition. Furthermore, critical or unresponsive actions in the previous turn followed by unresponsive evaluations typically indicate dismissals of different perspectives. Finally, long strings of supportive actions among different speakers broken by a critical action typically indicates a recognized misinterpretation.

The segments also suggested remedies for the problems of entrenched opposition, dismissal, and misinterpretation. Questions, particularly about other's experiences, provide a way out of entrenched opposition and dismissals by eliciting engagement to create a common base of understanding. Specific questions such as exact challenges (-R?'s) also invite clarifications of misinterpretations. In addition, elaborations of one's own perspective can help clarify misunderstandings.

Educators can use this framework both as a collaboration tool and as an assessment tool to help students benefit from their different individual experiences. Since specific actions constituted particular types of beneficial interactions, increased collaboration may result from encouraging those that facilitate collaboration and discouraging those that disrupt collaboration. Moreover, they can assess students' collaboration skills on-line in addition to examining the product of their collaboration.

Researchers can use this multi-dimensional framework of interactive properties within individual actions to analyze simultaneous multiple effects across cognitive, social and emotional domains. Cooperative group researchers have argued that students playing out particular roles (Cohen, 1986) or using specific strategies (Barnes & Todd, 1977; Cazden, 1988; Slavin, 1990)

increase the benefits of working together (or hinder the group's progress). However, these researchers have not addressed the possibility of simultaneous roles or strategies within one action. Consider for example, a student responding to a suggestion to add the time and the speed with "do you think we could multiply them instead?" This student is simultaneously a critic identifying a problem area, a proposer suggesting a new idea, and a facilitator both eliciting information and softening criticism (through a question rather than a statement). The multi-dimensional character of this framework can help researchers examine how multiple properties of an individual actions (or patterns of individual actions) interact simultaneously to influence the collaboration. In addition, researchers have analyzed human behavior separately at the social interactional and individual cognitive levels. This paper begins integrating the two analyses by introducing individual actions with social interactive properties. Finally, this study focused on the cognitive aspects of collaboration, but similar questions arise from considering social face, motivation, and emotions. Are there particular actions that create particular effects with respect to the social face, motivation and emotions of students working together? In addition, are these effects identical in different populations with respect to age, gender composition, culture, etc.? Finally, how can educators teach these skills to collaborating students effectively?

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Building on Diversity:

A moment-to-moment analysis of students collaboratively solving mathematics problems

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Abstract

Differences among students can yield rich benefits as well as pose difficult problems during collaborative learning. Students can draw upon their diverse individual experience to exchange information, to understand the different expressions of their shared commonalities and to jointly construct new possibilities. However, they also face the potential pitfalls of entrenching themselves in opposition to different views, dismissing other perspectives as less important or invalid, and misinterpreting other people.

To examine how individual actions create these benefits and problems, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive) , problem knowledge content (contribution, repetition, and null) , and interactive form (command, question, statement). Analysis of particular patterns of individual actions indicate how they create beneficial or harmful interactions.

Many educational researchers have focused on the needs of diverse students (Rose, 1989; Wong-Fillmore & Meyer, 1992) rather than the potential benefits of student differences. Instead of viewing differences as potential conflicts requiring additional resources, educators can use them as building blocks for learning. This paper examines the learning opportunities that arise from student differences during collaborative problem solving in an algebra class. By analyzing the students' moment-to-moment actions (Sacks, 1974; Schegloff, 1990), we can identify particular individual actions that facilitate (or hinder) students' collaborative learning.

I begin with a general analysis of three examples, showing the benefits and problems that arise from the students' discussion of their different perspectives. Then I consider properties of individuals' actions during these collaborative problem solving segments to create a theoretical framework of individual actions. Using this framework, I then re-analyze the three segments to show how particular individual actions facilitate (or hinder) the collaborative learning process. Finally, I conclude with a summary of the results and implications for educators/teachers and researchers.

BENEFICIAL AND PROBLEMATIC SOCIAL INTERACTIONS

Students can both benefit and suffer from discussing each other's perspectives. Advantages include exchanging information, recognizing shared commonalities, and jointly constructing new possibilities, while disadvantages include entrenched opposition, dismissal, and misinterpretation. Using three segments of student group work, I exemplify each of these advantages and disadvantages.

Potential Advantages

At the simplest level, students with different experiences know different things. As a result, students can benefit from exchanging information with one another. In the following segment, the students debunk each other's stereotypes about the weather in different regions of the United States while adapting the design of a college dormitory to a colder climate. Sitting at a

computer, the students have just calculated the average outside temperature in the new city Duluth, Minnesota and are choosing an appropriate thermostat setting for the dorm rooms.[1]

BE: It's about 45. [Fahrenheit, average Duluth temperature]

MO: Make it at least 19 degrees inside.

TK: I'll make it about 17. [TK as been controlling the computer mouse and enters 17 for the thermostat setting]

BE: It says 45. [looking at Celsius/Fahrenheit conversion chart in a book] The average in San Francisco is about 50

TK: That's about 10 Celsius. [3 second pause] Let's make it 15.

MO: That's too cold.

TK: That's not too cold.

Where did you live before you came here?

MO: Alabama.

TK: No wonder.

MO: It snowed in Alabama.

TK: Oh. [softly]

MO: [3 second pause] 8 inches.

TK: [slaps his hand to his open mouth in mock surprise]

BE: Al-a-bama.

MO: When's the last time it snowed here?

TK: Year before last. [5 second pause] Let's make it 15.

BE: That's 60 degrees!

TK: Uh-huh. [Enters 15 for outside temperature into the computer]

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[1]Each transcript is from videotapes of two seventh grade mathematics classrooms in two California urban public high schools. None of the students were friends before this group work, and they were not instructed on group work. They have been working together for over three weeks.

TK argues that MO believes an inside temperature of fifteen degrees Celsius is "too cold" because she's accustomed to the warmer climate of Alabama. When MO asserts "it snowed in Alabama," TK accepts this information with a soft "Oh" and momentary silence. "Oh" used alone with a falling intonation marks recognition or understanding (Schiffrin, 1987), and TK does not contest MO's assertion, suggesting acceptance. Likewise, when MO challenges TK to recall "the last time it snowed here [San Francisco]," TK's response "year before last" draws quiet acceptance from MO who does not contest TK's assertion. In both cases, one student provides new information that the other student accepts.[2]

Students can also learn that their individual experiences are different expressions of a shared commonality. Each individual experience is unique, but others may share facets of that experience. In the following segment, the students use their home experiences to decide how many bathrooms to put into a dormitory suite shared by eight students (same setting as the above segment).

MI: [controls the computer mouse and adds a wall in one bedroom of the dormitory blueprint]

SU: What is the space for?

Why are you putting a wall over there?

MI: It's for an extra bathroom!

SU: You're putting a bathroom over here right?

MI: We having three.

YO: Yeah. This is good. This is good. This is good.

SU: Three?

MI: Yeah.

[2]There are also problems in this interaction that I will address in the section on potential problems during collaboration.

SU: Why do you want three?

MI: Because there are eight people.

SU: So they should have two, one for every four people like in our apartment.

YO: Aren't we going thirteen by thirteen?

MI: I think they should have three bathrooms.

SU: How many people is at your house?

MI: Five.

SU: How many bathrooms are there?

MI: One. [3 second pause] Five one, four one, eight two. [deletes new wall for bathroom]

SU's home contains four people and one bathroom[3] whereas MI's home has five people and one bathroom. Yet, they build a shared sense that there should be two bathrooms for eight people, so MI deletes the wall for the proposed third bathroom. They need not have the exact same people-to-bathrooms ratio (indeed they could be 4:1 vs. 5:1), but their prescriptions sufficiently overlap in this problem to yield a common solution.

Finally, students can build on each other's ideas to jointly construct new alternatives, such as: proposals sparked by a comment, jigsaw pieces, and creative misinterpretations. In the preceding joint constructions, the first speaker contributes progressively more to the resulting proposal. Comments by one person, say a particular word, may spark another person to propose a solution. In addition, both people can put together different parts to create a full solution as jigsaw pieces fit together to complete a puzzle. Finally, one person may creatively misinterpret another person's proposal to construct a better proposal. In the following example, the students build on

[3]MI talked about her home in a later conversation.

each other's ideas to find one component for computing the slope of a pile of beans in a box.[4] Although they have computed the slope of two dimensional objects, such as lines, this is their first attempt to find the slope of a three-dimensional object.

MS: What's the slope?

RA: I don't know.

MS: What IS the slope?

RA: I don't know!

MS: No, I'm thinking. [laughs] I'm just asking myself.

RA: I said I don't know.[dramatic pained expression on face] [4 second pause] I can't even picture this in my mind.[picks up string]

MS: What's across from it? What's going that way? [moves horizontal pen back and forth]

RA: [drops string, picks up ruler and moves it into the box] From where? From the bottom?

MS: Yeah. From the bottom. Tilt it! [lifts a box corner up a bit]

RA: Wait! No! [keeps box down] Because we have to leave it like this. [Places ruler along the bottom of the box at the bean pile corner] It's like seven.

As evidenced by their "I don't know's," these students did not know a method for solving this problem. However, these students built on each other's piecemeal ideas. Responding to RA's comment that she "can't even picture this," MS asks about the horizontal dimension, "What's going that way? [moves horizontal pen back and forth]." Then, RA asks about "the bottom" of the pile, and MS concurs "from the bottom." RA's and MS's comments appear to have sparked

[4]To compute the slope of a bean pile, divide the pile's height by it's radius. In the case of a pile of beans against the corner of a box, the radius is the length from the box corner to the bottom edge of the bean pile.

jigsaw piece ideas that fit together to yield a measurement for the width component of the slope despite MS's misinterpretation of RA's intended measurement method.

Potential problems

In each of these segments, we also see problems that may arise including: entrenched opposition, dismissal, and misinterpretation. When students have invested themselves into particular positions, they may resist all attempts to persuade them. Rather than seeking information and understanding, they may entrench themselves in opposition to other students. This does not occur in any of these three segments, but we see initial steps on the path to entrenched opposition in the first two segments.

MO: that's too cold.

TK: that's not too cold.

SU: So they should have two, one for every four people.

MI: I think they should have three bathrooms.

In both segments, one person states their opposition to the previous speaker's position. At these moments, the collaboration could end with simple rejections of each other's position. In both cases, however, one person explored the other's background experiences to continue the collaboration.

TK: Where did you live before you came here?

SU: How many people is at your house?

Both students asked questions to find information that would support their own positions. Nevertheless they broke the entrenchment by asking about the other person's experience. Moreover, these questions signaled the validity of the other person's experience, building a foundation for a shared understanding.

Understanding another person's reasoning does not necessarily mean acceptance, however. A student can still dismiss it as unimportant or deny its validity entirely. In segment 1, TK acknowledges MO's assertion that "it snowed in Alabama" with an "oh."

TK: that's not too cold.

Where did you live before you came here?

MO: Alabama.

TK: No wonder.

MO: It snowed in Alabama.

TK: Oh. [softly]

However, he still sets the thermostat at fifteen degrees, ignoring MO and BE's protests.

TK: let's make it 15.

BE: that's 60 degrees!

TK: Uh-huh.

[enters 15 for outside temperature into the computer]

In this case, TK accepted the validity of MO's experience, but did not consider it sufficiently important to modify his decision.

Finally, students may misinterpret one another's assertions. To some extent, misinterpretation is unavoidable because people create unique understandings from their individual experiences, and they can not precisely articulate their views. Even when people apparently agree, they may still view the situation differently. In segment three, RA & MS apparently agreed to a particular measurement.

MS: What's across from it?

What's going that way? [moves horizontal pen back and forth]

RA: [drops string, picks up ruler and moves it into the box]

From where?

From the bottom?

MS: Yeah.

From the bottom.

Tilt it! [lifts a box corner a bit]

RA: Wait!

No! [keeps box down]

Because we have to leave it like this.

RA: [Places ruler along the bottom of the box at the bean pile corner] It's like seven.

However, when MS started to help RA measure, their differing perspectives became apparent. This segment also shows the appropriate responses in the face of misinterpretation, elicitation and elaboration. RA asks MS to clarify at the beginning of this segment and RA justifies her action of keeping the box down. (MS affirms at the beginning and her silence at the end suggests acquiescence.)

Individual differences during collaborative learning hold the promise of information exchange, recognition of shared commonalities, and joint construction of new possibilities if participants can successfully negotiate the pitfalls of entrenched opposition, dismissal, and misinterpretation.

INDIVIDUAL ACTIONS

Next, I consider how individual actions facilitate or hinder the negotiation of individual differences during collaborative learning. In this section, I present a framework of individual actions and then apply it to a re-analysis of the earlier three segments.

Each individual action is a sequence of one person's words, motions and/or drawings bracketed by pauses or falling intonations, e.g.: "what do we do next?" [shrugs his shoulders], and [writes "3 x 5 = 15" on the assignment sheet]. Between the actions of other people, a person may

perform one or more consecutive actions (a turn). Simultaneous actions (e.g. an utterance with a gesture) are identified separately, but are treated as one action in the analysis.

Interactive properties of individual actions

In the earlier discussions of each segment, contributions of new information, evaluations in the form of acceptance or criticism, and questions seemed to play important roles. Consider a brief exchange from the last segment:

RA: From the bottom?

MS: Yeah.

From the bottom.

RA's action is simultaneously a contribution of new information and a question inviting an evaluation. In contrast, MS's action does not contribute new information to the problem solution, is a statement, and also accepts the previous idea. Her second action is also a statement that supports the previous action and repeats all of RA's utterance.

Rather than simply listing different types of individual actions, I examine their interactive properties and the dimensions along which they lie. Using the above contrasts to form dimensions, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive), problem knowledge content (contribution, repetition, and null), and interactive form (command, question, statement). See figure 1.

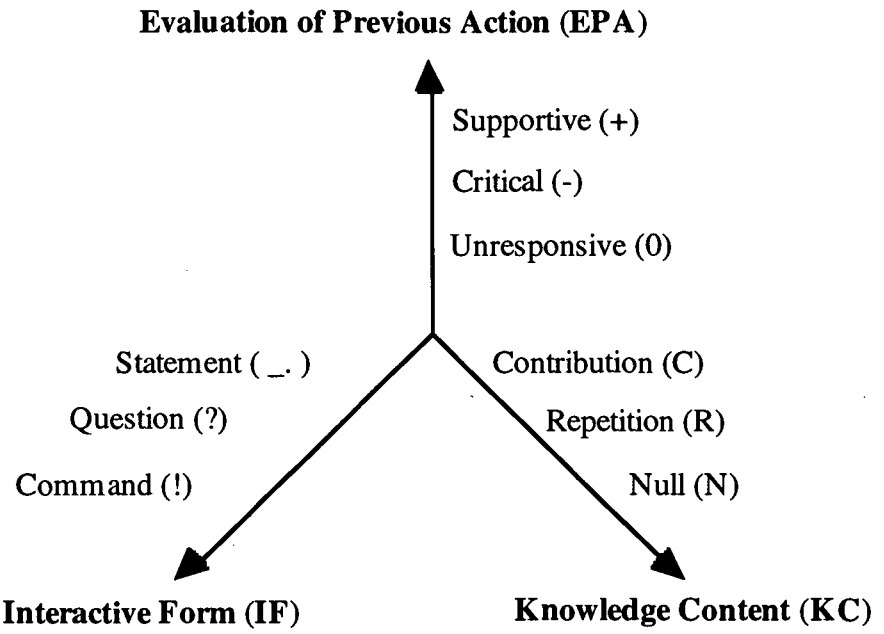

Figure 1. The dimensions and their properties that form the space in which I locate individual actions.

Evaluation of the previous action (EPA)

The evaluation of the previous action dimension characterizes how the current speaker assesses the previous action. After a person proposes an idea (e.g. "two hours times six miles per hour is ten"), one can support it entirely (+), reject at least part of it (-), or ignore it (0). (See figure 2.) Supportive actions (+) reinforce the direction of the current problem solving approach through acknowledgments ("yep"), justifications ("cause it only moves for two of the four hours"), criticism of alternatives ("times four hours assumes it's always moving"), etc. Finally, they encourage friendly social relationships through promoting positive social face (Brown & Levinson, 1987), especially if the participants invest themselves in their ideas.

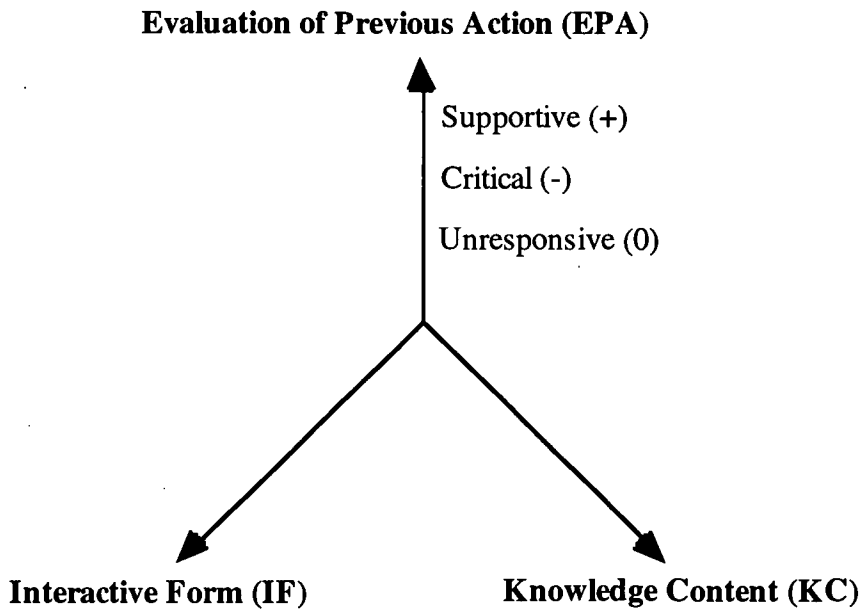

Figure 2. The evaluation of previous action dimension captures how the current action evaluates the previous action, supportively, critically, or unresponsively.

Criticism (-) includes both partial and total rejection. Partial rejection accepts the general framing of the proposal but notes errors ("twelve, not ten"), suggests related alternatives ("how about four hours times six?") or challenges some parts ("why two hours?"). In contrast, total rejection denies the validity of the whole frame of the proposal ("we have to find the acceleration, not the distance"). Since the distinction between partial and total rejection is difficult to delineate, I have chosen to group them together. Criticisms alter the problem solving trajectory by identifying flaws and opening alternatives. As before, if the previous speaker identifies his ideas with himself, cognitive rejection of the idea may also threaten psychological rejection of the person (especially without accompanying face-saving measures [Brown & Levinson, 1987]).

Finally, unresponsive actions (0) do not evaluate the previous action at all, initiating new topics instead ("is this on the quiz?").[5] Unresponsive actions draw the conversation away from

[5]One possible distortion may arise from a person presenting a series of proposals one after another in one turn. This analysis assumes that the speaker only evaluates the last action. If the person responds to any proposal except the last one, that act is coded as unresponsive (0). This is an issue for conversations in which people lay out a series of alternatives, for example in structured, management decision-making.

the previous speaker's solution approach entirely and pose a greater threat to the social relationship. They may present the worst threat to social face by ignoring the previous speaker's action, judging it as unworthy of comment. So, participants who initiate more new topics (through unresponsive actions) to which others respond show greater authority and control.

Knowledge content (KC)

The knowledge content dimension characterizes the problem knowledge displayed during the interaction and forms a continuum that includes non-overlapping contributions, overlapping contributions, synonymous repetitions, partial repetitions, exact repetitions, and null actions. (See figure 3.)

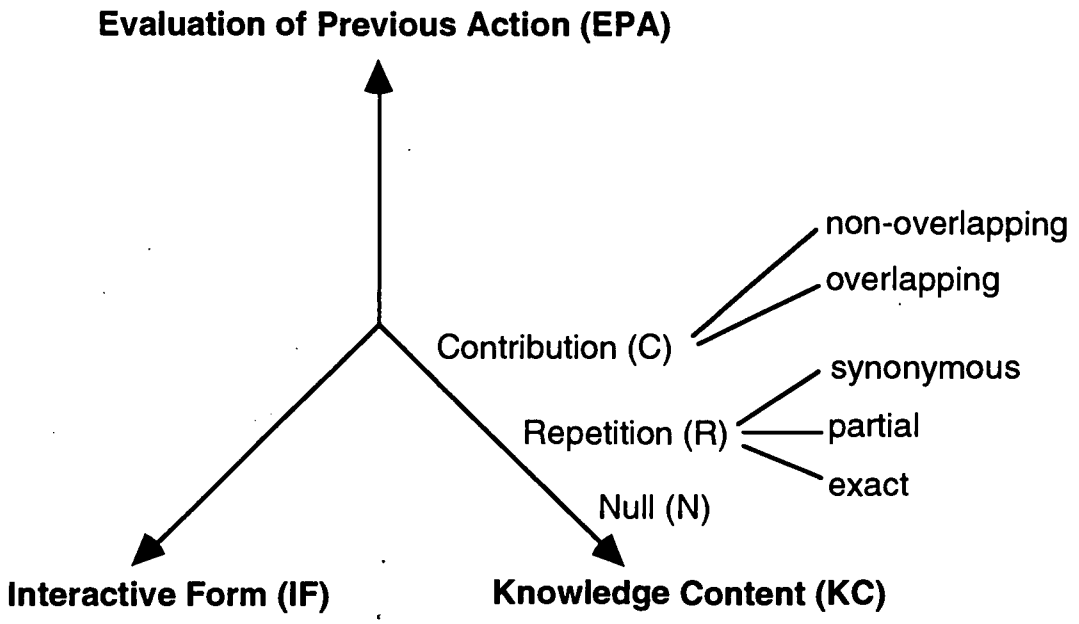

Figure 3. The knowledge content dimension describes the action with respect to a problem solution and to the knowledge content of previous actions. Contributions provide new information related to a solution and may overlap with an earlier contribution. Repetitions repeat an earlier contribution's ideas with synonyms or its words (either partially or exactly). Finally, null actions do not provide information related to a solution.

Consider each type of knowledge content in response to the phrase "two hours times six miles per hour." A non-overlapping contribution provides problem information without repeating any part of any previous action, e.g. "that'll give us the distance." In contrast, an overlapping contribution adds new information in combination with information from a previous action, "so the train moves twelve miles in two hours." In general, contributions (C) are new problem solving ideas or actions introduced into the collaboration and indicate moments of potential progress in the problem solving. Contributions include new goals, proposals, justifications, consequences, critiques, alternatives, and summaries. Tracing the contributions provides a map of the group's problem solving route. Meanwhile, repetitions (R) repeat the knowledge content of previous actions (not necessarily the immediately preceding one). Synonymous repetitions elaborate previous actions, but do not add significant new information, "two hours multiplied by six miles per hour." Meanwhile, partial and exact repetitions repeat part or all of a previous action precisely, "two times six" (partial)[6] and "two hours times six miles per hour" (exact). Repetitions can indicate the speaker's level of understanding and degree of agreement with previous contributions. Finally, null actions do not contribute specific, new problem-related information and do not repeat old information, "yeah." (Null actions can be repeated, but I always classify them as null actions, never repetitions.)[7] Since null actions are typically brief, they can provide feedback without interrupting the current speaker (backchannel responses).

Interactive form (IF)

The interactive form dimension describes the different degrees of encouragement for audience participation and includes at least three possibilities: statements, questions, and commands. See figure 4.

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[6]Partial repetitions must maintain the same meaning of the previous action, so negations by omission are contributions. "These birds can fly for two miles non-stop" is a contribution, not a repetition of "none of these birds can fly for two miles non-stop."

[7]Note that actions in off-task conversations are not labeled contributions. Instead, they are labeled as null content actions because they do not contribute to the problem solution.

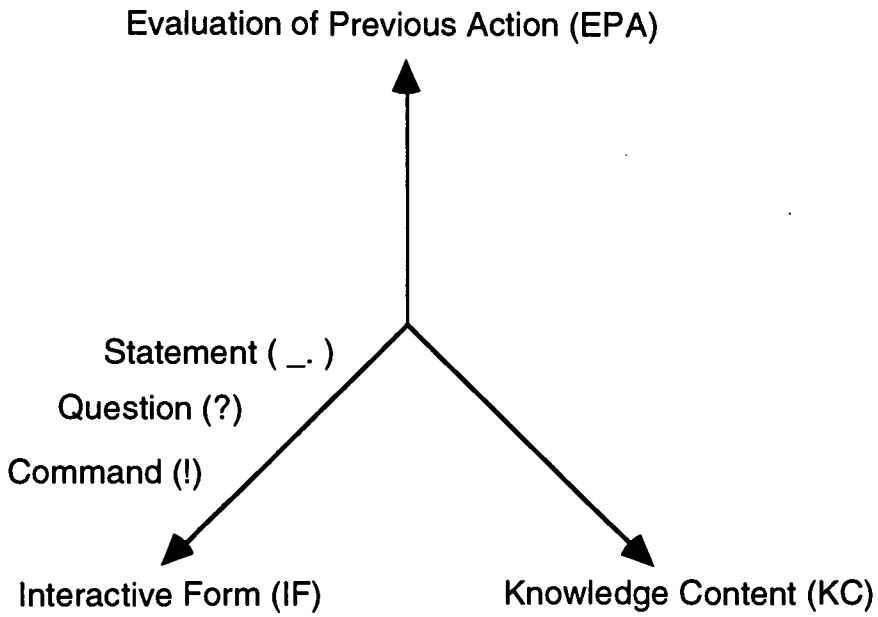

Figure 4. The interactive form dimension characterizes the degree in which a particular action invites participation from the audience. Statements, questions, and commands invite progressively more participation.

Statements (_.) declare information unintrusively, without eliciting participation from others. Virtually all the sentences in this paper are statements in which a subject precedes a predicate, e.g. "five times seven is thirty-four." In contrast, questions (?) invite audience participation intrusively by articulating an action/information gap for them to fill, thereby requesting an action. Typical questions end with rising intonations, e.g. "what's two times six?" Finally, commands (!) demand obedient audience participation without asking for their evaluation. Typical commands begin with verbs, "multiply two times six!"

The degree of interaction that these three forms initiate also vary within each form as well. The following types of statements elicit different degrees of participation: definitive vs. uncertain, summary vs. goal, and directives. Definitive statements discourage further discussion of what the speaker perceives to be a known truth ("two times six is twelve") while uncertain statements

encourage input on the validity of the statement ("two times six seems like twelve"). Likewise, summary statements tend to close interactions by articulating what the group has already accepted ("so we got twelve miles by multiplying two hours and six miles per hour") whereas goal statements encourage interaction by presenting a target towards which the group can work ("we need to find the distance"). Finally, directive statements present information that implies a directive toward action (Searle, 1969). The directive "two times six can't be ten" suggests that the audience recalculate the product of two and six. In short, definitive summaries, definitive goals, uncertain summaries, uncertain goals, and directives are all statements, but encourage successively greater participation.

Rhetorical, tag, choice, and open questions also initiate different degrees of interaction. Although the form of a rhetorical question invites responses ("can't you do anything right?"), the speaker knows the answer and does not expect a response. Tag questions follow statements and anticipate simple acknowledgments, "two times six is twelve, right?" Meanwhile, choice questions offer multiple possibilities from which the audience can select, "should we add or multiply?" Finally, speakers asking open questions do not restrict the answers and invite a greater variety of responses, "what should we do next?" Rhetorical, tag, choice, and open questions invite successively greater participation.

Finally, commands can also elicit different degrees of interaction. Although most commands demand audience action, blocking commands demand audience inaction, e.g. "wait!" Detailed commands specify particular actions, "measure the length of the box." Finally, open commands request general input from the audience, "give me your opinion." Blocking, detailed, and open commands demand increasingly greater audience participation.

The three major categories of interactive forms (statements, questions, and commands) generally encourage different degrees of audience participation, but they also vary within each

category. Future analyses may incorporate finer distinctions, but this paper only uses the major categories within each interactive dimension of analysis to define individual actions.

Types of Individual Actions

This section describes twenty-seven individual actions and their locations within the space created by the three dimensions of evaluation of previous action, knowledge content, and interactive form (see Table 1).

Table 1. Individual actions organized along three dimensions, evaluation of the previous action, problem knowledge content, and interactive form

Evaluation of Previous Action	Knowledge Content	Interactive Form		
		Statement (_.)	Question (?)	Command (!)
Unresponsive (0)	Contribution (C)	Announcement (0C_.)	Proposal (0C?)	Sudden order (0C!)
	Repetition (R)	Fixation (0R_.)	Echo request (0R?)	Echo command (0R!)
	Null (N)	External action (0N_.)	General request (0N?)	Starter (0N!)
Supportive (+)	Contribution (C)	Supportive addition (+C_.)	Supportive proposal (+C?)	Implementation command (+C!)
	Repetition (R)	Verification (+R_.)	Check of others (+R?)	Repeat commands (+R!)
	Null (N)	Acknowledgment (+N_.)	Supportive request (+N?)	Execution command (+N!)
Critical (-)	Contribution (C)	Critical addition (-C_.)	Counter-proposal (-C?)	Counter-order (-C!)
	Repetition (R)	Repeat Critique (-R_.)	Exact challenge (-R?)	Repeat counter-order (-R!)
	Null (N)	Denial (-N_.)	General challenge (-N?)	Halt (-N!)

I will begin with individual actions that ignore the previous action (0) and contribute new ideas (C): announcements, proposals, and sudden orders. Speakers using these actions attempt to close off the previous discussion/series of actions (if there were any) and/or initiate new (possibly parallel) conversations. As discussed earlier, unresponsive actions (0) can rupture the social fabric by rejecting the previous action (if any) as unworthy of comment. Announcements (0C_.) are statements that initiate a topic of discussion ("we have to find the distance") or that occur during brainstorming ("we can try graphing it"). Proposals (0C?) serve the same purpose, but also elicit evaluations from others ("are we finding the distance?"). Finally, sudden orders (0C!) demand implementation from the audience without requesting an evaluation ("find the distance" and "multiply two times six").

Now consider unresponsive actions (0) and repetitions (R): fixations, echo requests, and echo orders. By using these actions, the speaker reconsiders an earlier rejected or ignored idea without regard to the current conversation. Fixations (0R_.) indicate construction of new understanding of the old idea ("distance is rate times time!") or an attempt to do so ("rate times time ...") without intruding upon others. In contrast, echo requests (0R?) encourage others to consider a past idea ("rate times time equals distance?") while echo commands (0R!) demand that the audience act on a past idea ("multiply the rate and time again!").

The last set of unresponsive actions (0) are null actions (N) that ignore the previous action but do not specify another direction for the conversation: external actions, general requests, and starters. External actions (0N_.) indicate that the speaker is attending to something other than the problem solving activity ([looking out the window] or singing a tune "skiddly dee dop, da dee dop, da dee dop"). Meanwhile, general requests (0N?) invite others to participate in a new series of actions ("what are we supposed to do?") or to summarize ("what did we do?"). Finally, starters (0N!) initiate activities without specific instructions ("get to it!").

In short, people can ignore the previous action by contributing new ideas (announcements, proposals, and sudden orders), repeating past actions (fixations, echo requests, and echo orders), and performing null actions (distractions, general requests, and starters).

Next, I specify supportive evaluations (+), beginning with contributions (C): supportive additions, supportive proposals, and implementation commands. This set of actions justifies the previous action, articulates additional beneficial consequences and/or continues with an appropriate action. Supportive additions (+C_.) indicate that the speaker understands and accepts the previous action according to his/her own interpretation ("that gives us the distance"). Speakers may choose supportive proposals (+C?) that suggest less certainty to test their ideas or to test the other group members' understanding ("so that gives us the distance?"). Finally, speakers use implementation commands (+C!) to order others to perform consequent actions ("so multiply two and six").

People can support the previous action (+) by using repetitions (R) that indicate their understanding: verifications, checks of others, and repeat commands. Verifications (+R_.) may confirm understanding of the previous action ("twelve"), indicate that the speaker is trying to make sense of it ("times two ... is ... twelve"), or repeat the previous action to check its validity ([presses the following calculator keys: 2, x, 6, =] "twelve!"). To test whether the other group members understand the previous action, a person may use checks of others (+R?), typically through synonymous or partial repetitions ("hours times miles per hour is miles?"). People use repeat commands (+R!) to pass along the instruction to another person ("José, multiply two by six"), to repeat an ignored command ("I said multiply two by six"), or to repeat an incorrectly implemented command ("multiply two by SIX").

People can also support previous actions (+) through null actions (N): acknowledgments, supportive requests, and executions. By using an acknowledgment (+N_.), a person can indicate acceptance of the current speaker's idea without interrupting (backchannel feedback, e.g. "uh-huh" and [nods]). Supportive requests (+N?) include continuation requests and tag questions.

Continuation requests are open questions that ask for the next step in the solution, ("what's next?") while tag questions ask for confirmation of the previous action ("right?" expects a "yes" or "no" response). Finally, execution commands (+N!) affirm previous proposals (C?) and demand that others to act upon them ("do it").

In short, people can support the previous action by contributing new ideas (supportive additions, supportive proposals, and implementation commands), repeating past actions (verifications, checks of others, and repeat commands), and performing null actions (acknowledgments, supportive requests, and executions).

Finally, consider critical evaluations (-), beginning with contributions (C): critical additions, counter-proposals, and counter-orders. Critical contributions present new ideas that reject at least part of the previous action by providing an alternative, revealing a flaw in the reasoning, or showing an undesirable consequence. When using a critical addition (-C_.), a person objects to the previous action by presenting an alternative ("two PLUS six"), a revealed flaw ("the train only goes four hours"), or an unwanted consequence ("but by then the train has passed the car"). Counter proposals (-C?) soften critical suggestions by inviting others to evaluate the criticism ("shouldn't we multiply by two since the car only goes for two hours?"). As discussed earlier, the question form may also indicate low confidence in the suggestion ("should we multiply by two ..."). In contrast, a counter-order (-C!) not only criticizes the previous action but expects the audience to act immediately on a new order ("do two times six instead of four times six").

People can also criticize (-) through repetitions (R): repeat critique, exact challenge, and repeat counter-order. Repeat critiques (-R_.) reject the previous action by repeating an earlier action ("it's only going four hours") or by noting the violation of an earlier premise ("you said that it was only going four hours"). This tactic should be extremely persuasive if the audience had agreed upon the earlier premise. Exact challenges (-R?) soften premise violations ("didn't you say that it was only going for two hours?") or question the validity of the previous action by requesting

clarification ("it's going for two hours?") If a person issues a repeat counter-order (-R!), he/she has repeated an order over someone's criticism ("do two times six anyway!").

People also criticize (-) through null actions (N): denials, general challenges, and halts. Denials (-N_.), the mirror images of acknowledgments, provide negative backchannel feedback ("uh-uh" and [shakes her head]). Unlike exact challenges, general challenges (-N?) do not specify the area of concern ("why?"). Finally, people use halts (-N!) to prevent someone from performing an action ("stop!").

In short, people can criticize the previous action by contributing new ideas (critical additions, counter-proposals, and counter-orders), repeating past actions (repeat critique, exact challenge, and repeat counter-order), and performing null actions (denials, general challenges, and halts).

IMPACT OF INDIVIDUAL ACTIONS

Let us reconsider our earlier segments using the above framework to examine how patterns of individual actions may create beneficial or harmful situations.

Re-analysis of the first segment

In the re-analysis of the first segment, we can identify specific types of actions that account for the avoidance of entrenched opposition, the exchange of information, and the dismissal of different perspectives

EPA	KC	IF		
+	C	_.	BE:	it's about 45. [Fahrenheit, average Duluth temperature]
0	C	!	MO:	make it at least 19 degrees inside.
-	C	_.	TK:	I'll make it about 17.

+	C	_.		[has been controlling the computer mouse and enters 17 for the thermostat setting/inside temperature]
0	C	_.	BE:	it says 45. [looking at Celsius/Fahrenheit conversion chart in a book]
0	C	_.		the average in San Francisco is about 50
+	C	_.	TK:	that's about 10 Celsius
				[3 second pause]
0	C	!		let's make it 15
-	C	_.	MO:	that's too cold.
-	C	_.	TK:	that's not too cold.
+	C	?		Where did you live before you came here?
+	C	_.	MO:	Alabama.
+	N	_.	TK:	No wonder.
-	C	_.	MO:	It snowed in Alabama.
+	N	_.	TK:	Oh. [softly]
				[3 second pause]
+	C	_.	MO:	8 inches.
-	N	_.	TK:	[slaps his hand to his open mouth in mock surprise]
0	N	_.	BE:	Al-a-bama.
-*	C	?	MO:	When's the last time it snowed here?
-	C	_.	TK:	year before last.
				[5 second pause]
0	R	!		let's make it 15.
-	C	_.	BE:	that's 60 degrees!

+	N	_.	TK:	Uh-huh.
0	C	_.		[enters 15 for outside temperature into the computer]

* MO ignores BE's action and responds to TK's last action.

After BE computes the average outside temperature, MO initiates a new topic with a command (0C!) to set the thermostat at nineteen degrees. However, TK rejects it with an alternative (-C_.) After a few unresponsive turns, TK suddenly orders (0C!) implementation of a more extreme suggestion of fifteen degrees that MO critiques (-C_.). When TK rejects MO's criticism (-C_.), the students have an opportunity for rigidly holding their positions in entrenched opposition. Instead of simply holding his position through denials (-N_.) and repeat critiques (-R_.), TK asks MO to contribute information with a question (+C?). In general, eliciting information from others through questions (?) can provide a way out of fixed opposition. Moreover, questions are a standard linguistic tool for eliciting information. TK invites MO to talk about her previous experience with the weather to set up a criticism based on common ground. When MO answers (+C_.), TK accepts (+N_.) her information triumphantly. TK's supportive evaluation (+) of MO's assertion through his acknowledgment (+N_.) provides evidence that he accepts MO's information which otherwise can be contested. Students can also provide unsolicited information (C without an immediately preceding ?) as indicated in the next action. MO critiques TK's reasoning (-C_.) with a follow-up comment on the snow in Alabama. With considerably less enthusiasm, TK also acknowledges this information (+N_.). When MO further emphasizes this point with a supportive addition (+C_.) however, TK disparages (-N_.) her contribution, perhaps resenting her continued emphasis on this point. After BE's external action (0N_.), MO solicits information through a counter-proposal (-C?), challenging TK by asking him about his climate. TK's response (-C_.) draws silence and acceptance from MO. Despite apparently accepting MO's information, TK dismisses MO's different perspective and re-issues his echo command (0R!) of fifteen degrees. Furthermore, TK acknowledges (+N_.) BE's critique (-C_.), but proceeds to implement (0C_.) his

decision. In general, unresponsive actions (0) following another person's criticism (-) or unresponsive action (0) in the previous turn typically indicates dismissal of the other person's perspective.

In short, questions (?) provide a way out of entrenched opposition and elicit information (C) from others. However, the listener must accept the information, typically indicated by a supportive evaluation (+). Finally, critical (-) or unresponsive actions (0) in the previous turn followed by unresponsive evaluations (0) typically indicate dismissals of differing perspectives.

Re-analysis of the second segment

In the re-analysis of the second segment, we can identify specific types of actions that can initiate entrenched opposition and build shared commonalities.

EPA	KC	IF		
0	C	_.	MI:	[controls the computer mouse and adds a wall in one bedroom of the dormitory blueprint]
-	C	?	SU:	What is the space for?
+	C	?		Why are you putting a wall over there?
-	C	_.	MI:	It's for an extra bathroom!
-	C	?	SU:	You're putting a bathroom over here right?
-	C	_.	MI:	We having three.
+	N	_.	YO:	Yeah.
+	N	_.		This is good.
+	N	_.		This is good.
+	N	_.		This is good.
-	R	?	SU:	Three?
-	N	_.	MI:	Yeah.

-	R	?	SU:	Why do you want three?
-	C	_.	MI:	Because there are eight people.
-	C	_.	SU:	So they should have two,
+	C	_.		one for every four people like in our apartment
0	C	?	YO:	Aren't we going thirteen by thirteen?
-*	R	_.	MI:	I think they should have three bathrooms.
0	C	?	SU:	How many people is at your house?
+	C	_.	MI:	Five.
0	C	?	SU:	How many bathrooms are there?
+	C	_.	MI:	One.
				[3 second pause]
+	R	_.	MI:	Five one,
+	R	_.		Four one,
+	C	_.		Eight two.
+	C	_.		[deletes new wall for bathroom]

* MI criticizes SU's action, ignoring YO's recent comment.

At the beginning of this segment, MI unilaterally adds a wall to the floor plan to create an additional bathroom (0C_.). After MI explains this (C) in response to SU's questions (?), they argue over the desirability of three bathrooms. YO supports the current design (+N_.), but does not engage in the discussion. Although MI invites entrenched opposition through her denial (-N_.) and her repeat critique (-R_.), SU's questions (?) elicit MI's continued engagement in the discussion. MI responds to SU's exact challenge (-R?) by referring to the eight residents (-C_.), but SU critiques (-C_.) this reference by offering a specific ratio from her own home. Ignoring YO's unresponsive proposal (0C?), MI repeats her opposition (-R_.). SU tries another line of questions (?), this time asking MI about her experiences with people and bathrooms in her home.

After summarizing the ratios of SU's and her own different experiences through supportive repetitions (+R), she creates (+C) a shared conclusion ("eight two").

In short, denials (-N_.) and repeat critiques (-R_.) threaten to solidify opposition, but questions (?) elicit continued engagement and provide a way out of gridlock. Moreover, supportive repetitions (+R) of different perspectives (-C) followed by supportive contributions (+C) typically indicate the recognition of shared commonalities in the midst of different individual experiences.

Re-analysis of the third segment

In the re-analysis of the third segment, we can identify specific types of actions that can contribute to joint construction and indicate misinterpretation.

EPA	KC	IF		Actions
0	C	?	MS:	What's the slope?
+	N	_.	RA:	I don't know.
0	R	?	MS:	What IS the slope?
+	N	_.	RA:	I don't know!
-	N	_.	MS:	No,
+	N	_.		I'm thinking. [laughs]
+	N	_.		I'm just asking myself.
-	N	_.	RA:	I said I don't know.[dramatic pained expression on face]
0	C	_.		(4 second pause) I can't even picture this in my mind.[picks up string]
+	C	?	MS:	What's across from it?
+	C	?		What's going that way? [moves horizontal pen back and forth]

+	C	_.	RA:	[drops string, picks up ruler and moves it into the box]
+	C	?		From where?
+	C	?		From the bottom?
+	N	_.	MS:	Yeah.
+	R	_.		From the bottom.
+	C	!		Tilt it! [lifts a box corner up a bit]
-	N	!	RA:	Wait!
+	N	!		No!
+	C	_.		[keeps box down]
+	C	_.		Because we have to leave it like this.
+	C	_.	RA:	[Places ruler along the bottom of the box at the bean pile corner] It's like seven.

The short turns, absence of commands (!), and early null actions (N) suggested MS and RA's lack of a solution method. However, they begin building on each other's actions with supportive contributions (+C). MS also indicated her understanding through verifications (+R_.), and they elicited evaluations of their ideas through supportive proposals (+C?). This piece by piece joint construction contributes to the solution in this segment and eventually creates a correct solution in the following fifteen minutes. In general, joint construction occurs when students are cooperating, building on each other's ideas to create a new understanding that none of them could articulate before the interaction. The students cooperate with one another through evaluative contributions (+C and -C) and repetitions (R) in the form of questions (?) and statements (_.). Near the end of this segment, the string of supportive contributions (+C) suddenly ends with a halt (-N!), indicating a misinterpretation that RA corrects and explains with supportive additions (+C_.). Misinterpretations probably occur throughout the interaction because participants draw upon their individual experiences to construct unique understandings. Nevertheless, the overlaps in these

understandings may suffice for their immediate goals. However, misinterpretations arising from different perspectives stand out when a critical action (-) follows a long string of mutually supportive actions (+) among different speakers. Possible remedies for unclear interpretations include requests for clarification (+N?, -R?, and -N?) and elaboration of one's own views (+C). In this segment, MS and RA generally elaborated their own ideas.

In short, strings of evaluative contributions (+C and -C) and repetitions in the form of questions (?) and statements (_.) indicate joint construction while long strings of supportive actions (+) among different speakers followed by a critical action (-) typically indicates a recognized misinterpretation.

CONCLUSION

In this section, I briefly summarize the results at the segment and individual action levels before discussing the educational and research implications.

Differences among students can yield rich benefits as well as pose difficult problems during collaborative learning. Students can draw upon their diverse individual experience to exchange information, to understand the different expressions of their shared commonalities and to jointly construct new possibilities. However, they also face the potential pitfalls of entrenching themselves in opposition to different views, dismissing other perspectives as less important or invalid, and misinterpreting other people.

To examine how individual actions create these benefits and problems, I have constructed a three-dimensional space from the dimensions of evaluation of the previous action (supportive, critical and unresponsive), problem knowledge content (contribution, repetition, and null), and interactive form (command, question, statement). Particular patterns of individual actions indicate how students use their differences beneficially to exchange information, recognize shared commonalities, and jointly construct new possibilities as well as destructively to entrench themselves in opposition, dismiss other perspectives, and misinterpret other people. Questions

elicit information that are subsequently supported, typically through acknowledgments. Moreover, supportive repetitions of different perspectives followed by supportive contributions typically indicate the recognition of shared commonalities in the midst of different individual experiences. Meanwhile, strings of evaluative contributions and repetitions in the form of questions and statements create joint constructions. On the other hand, denials and repeat critiques threaten to entrench opposition. Furthermore, critical or unresponsive actions in the previous turn followed by unresponsive evaluations typically indicate dismissals of different perspectives. Finally, long strings of supportive actions among different speakers broken by a critical action typically indicates a recognized misinterpretation.

The segments also suggested remedies for the problems of entrenched opposition, dismissal, and misinterpretation. Questions, particularly about other's experiences, provide a way out of entrenched opposition and dismissals by eliciting engagement to create a common base of understanding. Specific questions such as exact challenges (-R?'s) also invite clarifications of misinterpretations. In addition, elaborations of one's own perspective can help clarify misunderstandings.

Educators can use this framework both as a collaboration tool and as an assessment tool to help students benefit from their different individual experiences. Since specific actions constituted particular types of beneficial interactions, increased collaboration may result from encouraging those that facilitate collaboration and discouraging those that disrupt collaboration. Moreover, they can assess students' collaboration skills on-line in addition to examining the product of their collaboration.

Researchers can use this multi-dimensional framework of interactive properties within individual actions to analyze simultaneous multiple effects across cognitive, social and emotional domains. Cooperative group researchers have argued that students playing out particular roles (Cohen, 1986) or using specific strategies (Barnes & Todd, 1977; Cazden, 1988; Slavin, 1990)

increase the benefits of working together (or hinder the group's progress). However, these researchers have not addressed the possibility of simultaneous roles or strategies within one action. Consider for example, a student responding to a suggestion to add the time and the speed with "do you think we could multiply them instead?" This student is simultaneously a critic identifying a problem area, a proposer suggesting a new idea, and a facilitator both eliciting information and softening criticism (through a question rather than a statement). The multi-dimensional character of this framework can help researchers examine how multiple properties of an individual actions (or patterns of individual actions) interact simultaneously to influence the collaboration. In addition, researchers have analyzed human behavior separately at the social interactional and individual cognitive levels. This paper begins integrating the two analyses by introducing individual actions with social interactive properties. Finally, this study focused on the cognitive aspects of collaboration, but similar questions arise from considering social face, motivation, and emotions. Are there particular actions that create particular effects with respect to the social face, motivation and emotions of students working together? In addition, are these effects identical in different populations with respect to age, gender composition, culture, etc.? Finally, how can educators teach these skills to collaborating students effectively?

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