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ABSTRACT

This study investigated how different components of teacher/teaching assistant interventions improved or reduced student motivation. The study was part of a larger project in which ethnically diverse students were videotaped during their 5 algebra classes for 6 weeks in their urban public high school. A total of 40 students (10 groups of 4) from 5 different classes were videotaped while collaboratively solving an algebra problem. Two teachers and three teaching assistants (TAs) taught the classes. They allowed the groups of students to work on the problem for 20 minutes, monitoring their progress with occasional interventions. Researchers coded all speaker turns and the resulting information. Data analysis indicated that teacher/TAs significantly affected student motivation. At the activity level, higher student motivation increased collaborative problem solving success. At the intervention level, student-initiated interventions, teacher/TA support, criticism, questions, closed questions, and compliments all increased student motivation (showing the importance of low teacher involvement, student autonomy, and relevant closed questions). Greater teacher/TA involvement decreased student motivation. Teachers and TAs intervened more often with groups that showed less problem- solving progress and offered those students less autonomy. A case study of a TA's use of compliments showed positive effects on student motivation. The TA satisfied a student's bid for attention without compromising mathematical standards of evaluation. (Contains 20 references.) (SM)

Teachers effects on student motivation during group work:

Activity and intervention level analyses

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Abstract

Teacher interventions influenced student motivation during group work. Forty students (10 groups of 4) from five different ninth grade classes were videotaped while collaboratively solving an algebra problem. Two teachers and three teaching assistants (TAs) taught these classes (one teacher and one TA per class) and intervened 54 times. At the activity level, higher student motivation increased collaborative problem solving success. At the intervention level, student-initiated interventions, teacher/TA (T/TA) support, criticism, questions, closed questions, and compliments all increased student motivation, showing the importance of low teacher involvement, student autonomy, and relevant closed questions. Furthermore, greater T/TA involvement decreased student motivation. In addition, T/TA intervened more often with groups showing less problem solving progress and offered these students less autonomy. Finally, a case study of a TA compliments' positive effects on student motivation showed that the TA satisfied a student's bid for attention without compromising mathematical standards of evaluation.

Teachers' effects on student motivation during group work:

Activity and intervention level analyses

Motivation is central to student achievement. Students who are motivated to learn about a particular topic perform better than their less motivated peers (Ames & Ames, 1984, 1985; Stipek, 1988). Researchers have argued that many factors can improve student motivation (e.g., a challenging complex problem [Stodolsky, 1988], a caring classroom environment [Caballo and Terrel, 1994], etc.). In particular, researchers have argued that both teachers (Ames & Ames, 1985; Brophy, 1983) and cooperative learning (Caballo & Terrel, 1994; Slavin, 1990) can improve student motivation. In this study, I examined how teachers increased (and decreased) students' motivation by talking with them during collaborative problem solving. By identifying effective and ineffective intervention methods, educators can improve student motivation and learning. Through videotape and statistical analyses of 40 students and five teacher/teaching assistants (T/TA), this study tested how different components of teacher/teaching assistant interventions (TI) improve or reduce student motivation.

Conceptual perspective

In this study, I focused on teacher involvement and student autonomy as teachers intervened in student group work. Involvement includes both engagement and responsiveness. Skinner and Belmont (1993) showed that greater teacher engagement through devotion of time, affection, and resources (as opposed to rejection and neglect) predicted greater student motivation throughout the school year. Likewise, researchers have shown that teacher guidance and explanations encourage student engagement and improve student motivation (see Brophy's [1986] review). However, unsolicited help can harm students by threatening their autonomy and by inducing them to believe that they have low ability and need help (Graham, 1990). Likewise, Cohen (1994) argued that a teacher should only intervene in student group work when the group is off-task or involved in an interpersonal conflict. At other times, she argued, the students should rely on themselves rather than depend on the teacher. So, teacher engagement may not increase student motivation when it is unsolicited and when providing help encourages student dependence on the teacher.

Responsiveness includes both listening to students' utterances and evaluating them. Keller (1983) argued that teachers increase students' motivation by listening to them and providing relevant feedback. Brophy (1983) claimed that praising students contingently (as opposed to undeserved praise and compliments) highlights students' competencies and focuses their attention on their task-relevant behaviors. However, Graham (1990) showed that 11-12 year old students viewed praise and blame as indicators of effort and inverse indicators of ability, so praise suggested more effort was needed compensate for less ability. Consequently, she recommended that teachers blame students for failure and avoid praise for success, especially on easy tasks. So, teachers should listen to students and evaluate directly rather than skewing evaluations toward praise and avoiding blame.

Researchers have also argued that students with greater autonomy are more motivated because their motivation is intrinsic, whereas extrinsic motivation through reward structures eventually undermines itself (see reviews by Brophy [1986] and Grolnick, Ryan, & Deci [1989]). At the utterance level, teachers can influence student autonomy through invitational form and open-endedness. Teachers can invite participation through questions or demand participation through commands (Chiu, 1997). Furthermore, researchers have argued that the teacher can allow students more freedom with open questions or constrain students to specific responses with closed questions (Buzzelli, 1996; Greenberg, Woodside & Brasil, 1994). However, scaffolding advocates (Rogoff & Gardner, 1984; Wood, Bruner & Ross, 1976) argued that teachers must adapt their questions to the students' responses, implying that closed questions must follow open questions. Group problem solving differs from a class discussion in this respect because there is already an open question equivalent, namely how to solve the problem. Furthermore, a teacher encounters students already working on a particular part of the problem. Instead of asking a distracting open question, an adaptive teacher may ask a closed question specific to the students' problem solving.

In this study, I tested the following hypotheses.

Hypotheses

I. Higher student motivation increases group problem solving success.

II. Teacher-initiated interventions in student group work decreases student motivation.

III. Responsive or contingent praise increases student motivation.

IV. Responsive or contingent criticism increases student motivation.

V. Greater quantity (e.g. words) of teacher involvement in student group work decreases student motivation.

VI. Greater quality (e.g. problem solving content) of teacher involvement in student group work decreases student motivation.

VII. Teacher questions increase student motivation.

VIII. Teacher commands decrease student motivation.

IX. Closed, not open, teacher questions increase student motivation.

X. Open teacher questions followed by closed teacher questions does not increase student motivation.

XI. Non-contingent praise or compliments decrease student motivation.

Figure 1 shows the temporal and causal relationships in my model. Pre-TI student and group properties influences who initiates the TI which in turn influences the actions during the TI. These properties may all affect the students' post-TI motivation. Before the

TI, students in a group were motivated at a particular level and made progress on the problem solving to some degree. Research showed that student motivation predicted achievement (Ames & Ames, 1984; Stipek, 1988) and student achievement did not predict motivation (Crandall, 1969; Stipek & Hoffman, 1980). Next, either the student or the teacher initiated a TI with the group. During that TI, the teacher evaluated the students, provided input, and elicited student input. In addition, the teacher may also offer compliments. All of these actions may affect the students' motivation after the teacher leaves the group.

Insert figure 1 about here

Methods

I tested the effects of motivation on problem solving and of intervention variables on student motivation by coding videotape transcripts and statistically analyzing groups of students solving a math problem and T/TAs' actions during TIs.

Participants

This study was part of a larger project in which we videotaped ethnically diverse students (38% African-American, 32% Euro-American, 20% Asian-American and 10% Latino-American) during their five algebra classes for six weeks. Two teachers and three teaching assistants (TA) taught the classes (one teacher and one teaching assistant per class) in an urban, public high school. (All teachers and TAs were Euro-American). The teachers randomly assigned students into groups, and the students did not receive any group work training. The teachers had taught for 10 and 11 years, and the TAs were education doctoral candidates with 2-5 years of teaching experience. The ten videotapes were of 40 students (ten groups of four) across five classes doing one lesson near the end of a six week unit on functions so that the T/TAs had some experiences with student group work.

Procedure

After a teacher introduced the following problem below in each class, the student groups worked on it for 20 minutes while the teacher and TA monitored their progress with occasional interventions:

> Nintendo charges $180 for each gaming system and $40 for each video game. Sega charges $120 for each gaming system and $50 for each video game. How many games must a customer buy to pay less for Nintendo than for Sega? (Note: customers must buy a gaming system before buying any video games.)

The team of teachers and researchers believed that this was a difficult problem for these students even though they had covered enough mathematical concepts and relationships in class to solve it. There are algebraic, graphical and tabular methods to find the number of games purchased in which the cost is same for either brand. Students could set the cost equations equal to each other and solve for the number of games: $180 + 40g = 120 + 50g \rightarrow 60 = 10g \rightarrow 6 = g$. Students could also graph each equation and find the intersection of the lines: $y = 180 + 40x$, $y=120 + 50x \rightarrow (x,y) = (6, 420)$. Finally, students can add additional games and compute the cost until the costs are equal (see table 1). The correct answer is obtained by adding an additional game (6 + 1 or 7 games) so that the cost of buying Sega exceeds that of buying Nintendo.

Insert table 1 about here

Variables

A colleague and I coded all speaker turns (tested with Cohen's kappa), and we consensually resolved remaining differences.

Mathematics achievement. I used the students' mid-year algebra grades to compute the mean grade for each group.

Student motivation. We coded each student's motivation for each minute of the group work. Possible motivation codes were engaged (working on the problem), inattentive (looking out the window), and active distraction (talking off-task), respectively 1, 0, and -1. The group motivation was the mean of all the members' motivations. To avoid the effect of student role-playing in front of the teacher, I used students' motivations 30 seconds before the teacher arrived at the group (pre-TI) and 30 seconds after the teacher left (post-TI).

Solution score. Each group received a single final solution score (0 -3) (see Appendix A for coding details). Before each TI, my colleague and I coded the group's problem solving progress with the same scoring system.

Words. I counted the total number of words spoken by all participants during a TI and computed the percentage of words spoken by T/TA.

Intervention initiation. Either a student (0) or a teacher (1) initiated each an TI.

T/TA content. During an intervention, a T/TA may give no solution information (0), draw attention to a part of the problem or the students' solution (1), provide part of the solution (2), or demonstrate the entire solution (3).

T/TA evaluation turns. A T/TA can support, criticize, or ignore the last speaker. (See Appendix A for coding details.)

T/TA invitational turns. T/TAs can use commands, questions or statements to address students. Questions may be open or closed. The "closed/question" variable is the number of closed questions during a TI divided by the total number of questions during a TI. Also, I created an "open before closed" variable which tracked whether a T/TA's open question(s) preceded at least one closed question (1), whether closed questions preceded all open questions (-1), or neither (0).

T/TA compliments. Compliments are attributions of a person ("good thinking") and differ from evaluations of solutions ("correct"). TIs can include T/TA compliments (1), T/TA insults (-1), or neither (0).

I applied a logit transformation on all percentages to address tail effects.

Levels of analysis

Activity level: motivation and problem solving. I correlated mean mathematical grade for each group with their mean motivation. Then, I controlled for mathematical grade while correlating mean motivation with final solution score.

Intervention level: predicting student engagement after TI. In the hierarchical regression and path analyses, I entered student properties before TI properties to predict student motivation. Research showed that student engagement predicted problem solving, so I entered those variables in that order. Next, either a teacher or a student initiated a TI. During the TI, the T/TA evaluated the students with supportive or critical actions (or ignored them), so I entered those variables together.

The T/TA then shaped the quantity and quality of the TI. Total words tested the effect of overall quantity of talk and served as a control for frequencies of the remaining variables. Next, I tested the percentage of words spoken by the T/TA, followed by his or her content contribution to the problem solving.

Then, the T/TA invited student input. The teacher used questions or commands (or statements to avoid directly inviting student input), so I entered those variables together. Next, I tested the role of open vs. closed questions with the closed/questions ratio, followed by a test of whether open questions preceded closed questions. Finally, I tested the effect of T/TA compliments.

In short, the hierarchical regression and path analyses predicted post-TI student engagement with: (a) pre-TI student engagement, (b) student problem solving progress, (c) student vs. T/TA initiation, (d) percentages of T/TA supportive and critical actions, (e) total words during the TI, (f) percentage of TI words by T/TA, (g) T/TA problem solving content rating, (h) percentages of T/TA questions and commands, (i) percentage of T/TA closed questions (out of total questions), (j) score of T/TA open questions before closed questions, and (k) T/TA compliment.

Episode case study. Because of the surprising results for T/TA compliments, I included a case study of a single representative episode.

All results were significant at the .05 level.

Results

Activity level: motivation and problem solving

The students found this problem difficult as only half of the groups correctly solved it (see table 2). Of the 784 student-minutes coded for motivation, students were engaged 63% of the time, inattentive 19% of the time and actively distracting 18% of the time (Cohen's kappa = .88, $p < .001$). The T/TAs intervened in the students' group problem solving 54 times, speaking for 269 turns. The T/TA turns were 55% supportive, 25% critical, and 20% unresponsive to the previous student speaker (kappa = .89, $p < .001$). T/TAs' invitational forms included 45% questions , 5% commands and 50% statements, (kappa = .96, $p < .001$). Finally, T/TAs complimented students on 3% of their turns (kappa = 1, 100% agreement). Surprisingly, there were two teacher insults of students, with predictably negative effects on student motivation.

Insert table 2 about here

Average student engagement predicted the group's final solution score. As expected, mean mid-year mathematics grade did not significantly correlate with mean group engagement (r = .48). After controlling for grade, group mean motivation significantly correlated with solution score ($r = .69$, $p < .05$)

Intervention level: predicting student engagement after teacher intevention

As shown in table 3, TIs could both increase and decrease student engagement, though the mean effect of these TIs did not significantly increase student motivation (from .18 to .19). T/TAs initiated most of the TIs (74%), at which time the students were generally less engaged (.18) than usual (.45). During the TIs, T/TA offered more critical evaluations (.44) than supportive ones (.33), and spoke fewer than half of the words (45%). Furthermore, T/TAs used more questions (41%) than commands (22%) and many more closed questions (76%) than open questions (24%).

Insert table 3 about here

Percentages of T/TA support, criticism, questions, and closed questions, and T/TA compliments positively predicted post-TI student engagement (see table 4). Meanwhile T/TA initiation and percentage of words by the T/TA negatively predicted it. T/TA initiation, and percentages of T/TA support, criticism, questions, and compliments showed both significant total and direct effects. The significance of both supportive and criticism variables suggested that T/TA responsiveness and feedback motivated students, regardless of the judgment. Furthermore, the results supported the student autonomy hypotheses by showing that post-TI student engagement increased after TI's in which (a) students initiated, (b) students talked proportionately more, (c) the T/TA invited students to contribute with proportionately more questions, and (d) the T/TA used more focused, closed questions rather than distracting, open questions. I analyzed the surprising positive effect of T/TA compliments on student motivation in a case study at the end of this section. Using only the significant variables in a hierarchical regression yielded similar results (see appendix B).

Insert table 4 about here

Meanwhile, pre-TI student engagement, student problem solving progress, total words, T/TA content and T/TA open questions before closed questions did not significantly predict post-TI student engagement. The surprising lack of correlation between pre-TI and post-TI student engagement suggested that student engagement is malleable during a TI. Consistent with the research literature (Crandall, 1969; Stipek & Hoffman, 1980), student problem solving progress did not affect post-TI student engagement. Also as expected, the percentage of words spoken by the T/TA was more important than the total words in the TI. T/TA contents either did not significantly affect student motivation or had opposite effects in different situations. As argued earlier, the collaborative activity may have served as an open question, so the preceding, distractive, open questions were balanced by the following, focused, closed questions, and they did not significantly affect student motivation in one direction.

The path analysis showed that T/TAs initiated TIs more often in groups that showed less problem solving progress and possibly needed more help. During these TIs, T/TAs generally offered these students less autonomy.

T/TA-initiated TIs positively predicted percentage of supportive T/TA actions, but negatively predicted T/TA criticism, suggesting concern for social affiliation with students (see table 5). Furthermore, T/TA initiation positively predicted percentage of words by the T/TA, suggesting that the T/TA tended to dominate more of these discussions. Meanwhile, T/TA criticism and support both negatively predicted percentage of words by the T/TA, implying that T/TAs who were more responsive to students also spoke relatively less. Not surprisingly, T/TAs who spoke more often during the TI also provided more substantial problem information (T/TA content).

Insert table 5 about here

Pre-student motivation and student problem solving progress both positively predicted percentage of T/TA questions and negatively predicted percentage of T/TA commands. These results suggested that T/TAs give more engaged and more successful groups more autonomy by asking them to show knowledge rather than demanding that they follow instructions. Likewise, percentage of T/TA support and criticism also negatively predicted percentage of T/TA commands, showing a consistent attitude that T/TAs often both are responsive towards and offer greater autonomy to the same student groups. In two additional consistent displays of student autonomy allocated by the teacher, percentage of words by T/TA negatively predicted percentage of T/TA questions and commands. Finally, percentages of T/TA support and questions positively predicted T/TA compliments, suggesting that a T/TA used compliments for groups (or specific students) that he or she perceived as needing support and gentle invitations to participate.

Case study of compliment effects

In this case study, I examined how a TA facilitated a student group's (PA, KA, LO, and EM) collaborative problem solving with a compliment. PA had been dominating the conversation with disruptive questions about KA's personal life. KA and LO had also engaged in off-task conversations, but EM had been silent for the entire group problem solving session thus far (eight minutes). In the midst of an off-task conversation, TA walked by the group.

[1:03:18 - 1:05:11]

LO: Let me see your ruler. [takes ruler from KA's side of the table]

TA: [walks by the group, bends over behind LO and EM, smiles] You guys got an answer yet?

PA: No.

LO: We're just starting.

TA: [looks at LO's paper] Well, I see somebody doing at least the graph part right, anyways.

PA: Yeah, it looks just like mine. [PA has not drawn a graph]

TA: [Smiles at PA] That's a nice shirt, by the way, that you have on.

PA: Thank you.

TA: You're welcome.

[After 7 seconds of silent individual work, TA leaves.]

LO: I got a five games thing. Is it like a five thing. It's like 10, 20, 30, 40 like that? [while counting, his right hand bounces along his graph]

KA: I guess, it's like 10, 20, 30, 40. Do a table for it.

LO: What about for the top one? You know, it's by ones, right? It's like 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.

EM: This is for games? [points with pencil to paper]. Then what's this?

PA: You have money, it's for games. This is for one, this is for two [meanwhile, PA's finger taps EM's paper]

TA's brief social interaction had a dramatic effect on the group: PA started working on the problem, LO initiated a problem topic, and EM spoke for the first time this period. After asking a closed question ("got an answer yet?"), TA learned that they made little progress ("No." "We're just starting"). Yet, he did not intrusively engage them with demonstrations or probing questions. Instead, he highlighted desirable productive behavior by praising LO's graph ("I see somebody doing at least the graph part right"). Despite his recent disruptive behavior, PA accepted this standard of assessment and drew attention to himself by falsely claiming credit for a similar graph ("it looks just like mine"). Rather than challenging the validity of PA's claim, TA directed praise toward PA as well by complimenting him on his shirt ("[smiles at PA] That's a nice shirt"). PA accepted this praise ("Thank you") and started working on the problem. Shortly after TA left, LO capitalized on TA's validation of his graph to initiate a discussion of it. KA, EM, and PA all engaged in the conversation, initiating proposals or questions.

In this episode, TA's compliment served a particular purpose: he satisfied a student's specific bid for attention without compromising his mathematical standard of evaluation. After showing approval of a student's productive work, the TA did not lower his mathematical standard to praise a student who had not done the work. Instead, he showed his social affiliation with the student by complimenting him outside the mathematical realm, on the students' sartorial judgment. Finally, he only complimented the student who bid for attention and did not dilute the value of the compliment by praising others who did not ask for attention.

Conclusion

In short, T/TAs significantly affected student motivation. The data supported all the hypotheses except for VI (T/TA content) and XI (compliments). At the activity level, higher student motivation increased collaborative problem solving success. At the intervention level, student-initiated TI's, T/TA support, criticism, questions, closed questions, and compliments all increased student motivation, showing the importance of low teacher involvement, student autonomy, and relevant closed questions. Furthermore, greater T/TA involvement decreased student motivation. In addition, T/TAs initiated TIs more often in groups that showed less problem solving progress and offered these students less autonomy. Finally, a case study of T/TA compliments' positive effect on student motivation showed that its success stemmed from satisfying a student's bid for attention without compromising mathematical standards of evaluation.

Limitations and future research

Many questions still remain. First and foremost, can these results be replicated with larger and more diverse samples? In particular, the low power of these tests reduces confidence in the insignificant results. Do these teacher behaviors yield similar results when students collaborate on less defined problems or tasks in different subjects? Do successful teachers adapt their interventions to different students? If so, what are the different types of interventions? What criteria do they use – problem solving progress, level of students' social interaction, and/or past student achievement? By answering these questions, educators can help students work together more productively.

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Appendix A: Coding Solution Score and Speaker Turns

Solution score:

Correct answer:	3 points
Articulated a correct solution method:	2 points
Articulated the correct goal and problem situation:	1 point

Goal: Finding the critical number at which the cost for each product is identical

Problem situation:

Cost is computed by price of system plus price of each game.

Each company has different prices for their system and their games

None of the above:	0 points

Code each speaker turn along the 3 following dimensions:

Evaluation:

Does the speaker respond to the previous speaker?

No, code as unresponsive

Yes, does the speaker fully agree with the previous speaker?

Yes, code as supportive

No, code as criticism

Invitational form:

Does the speaker demand action (or inaction) from one or more listeners?

Yes, code as command

No, does the speaker ask someone to participate?

Yes, code as question

Can the question be answered correctly in less than 5 words?

Yes, code as open question

No, code as closed question

No, code as statement

Personal Judgment:

Does the speaker attribute a specific positive personal characteristic to a listener?

Yes, code as compliment

No, does the speaker attribute a specific negative personal characteristic to a listener?

Yes, code as insult

No, code as non-personal

Appendix B: Hierarchical regression and path analysis

on reducted set of significant variables

Hierarchical regression on post-teacher/TA intervention student motivation using only significant variables from the full regression

	Total Effect β	Direct Effect β	Variance R^2
T initiates	-.40 **	-.33 ***	.16 **
% T supports	.89 ****	.65 ****	
% T criticizes	.66 ****	.56 ****	.48 ****
% Words by T	-.30 **	-.21	.04 *
% T questions	.20 *	.31 *	.03 *
% T closed /questions	.17 *	.16	.03 *
T compliments	.18 *	.18 *	.03 *
Total R^2			.77 ****
Adjusted R^2			.72

Path analysis using only the significant variables from the full regression

	% T Support	% T Criticize	% T Words	% T question	% T closed /questions	T compliment
T initiates	.42 **	-.49 ***	.45 ***	.12	.05	.02
% T support			-.57 ***	-.06	.05	.51 **
% T criticize			-.47 **	-.15	-.24	.05
% T words				-.70 ***	.22	-.45 *
% T question					-.33 *	-.28
% T closed /questions						

Table 1.

A tabular solution created by adding the cost of successive games

Games	Nintendo Cost	Sega cost
0	180	120
1	220	170
2	260	220
3	300	270
4	340	320
5	380	370
6	420	420
7	460	470

Table 2.

Summary statistics at the activity level

Variable	Mean	Std Dev	Minimum	Maximum
Final solution score	1.8	1.3	0	3
Mean math grade	79	7	71	89
Mean student engagement	.18	.36	-.40	.67

Table 3.

Summary statistics at the intervention level

Variable	Mean	Std Dev	Mininum	Maximum
Number of interventions per group	5.4	2.8	2	10
Difference in motivation	.25	1.2	-1.5	2.0
S engagement after T intervention	.19	.83	-1.00	1.00
S engagement before T intervention	.18	.78	-1.00	1.00
S problem solving progress	.89	.88	0	2
T initiates	.74	.44	0	1
% T supports	.33	.48	.00	1.00
% T criticizes	.44	.50	.00	1.00
Total Words	147	1277	4	557
% Words by T	.45	.24	.05	.96
T content	.70	.82	0	2.00
% T questions	.41	.35	.00	1.00
% T commands	.22	.37	.00	1.00
% T questions, closed	.76	.30	.00	1.00
T questions - open before closed	.39	.53	-1.00	1.00
T compliments	.15	.45	-1.00	1.00

Table 4.

Hierarchical regression predicting student motivation after a teacher intervention

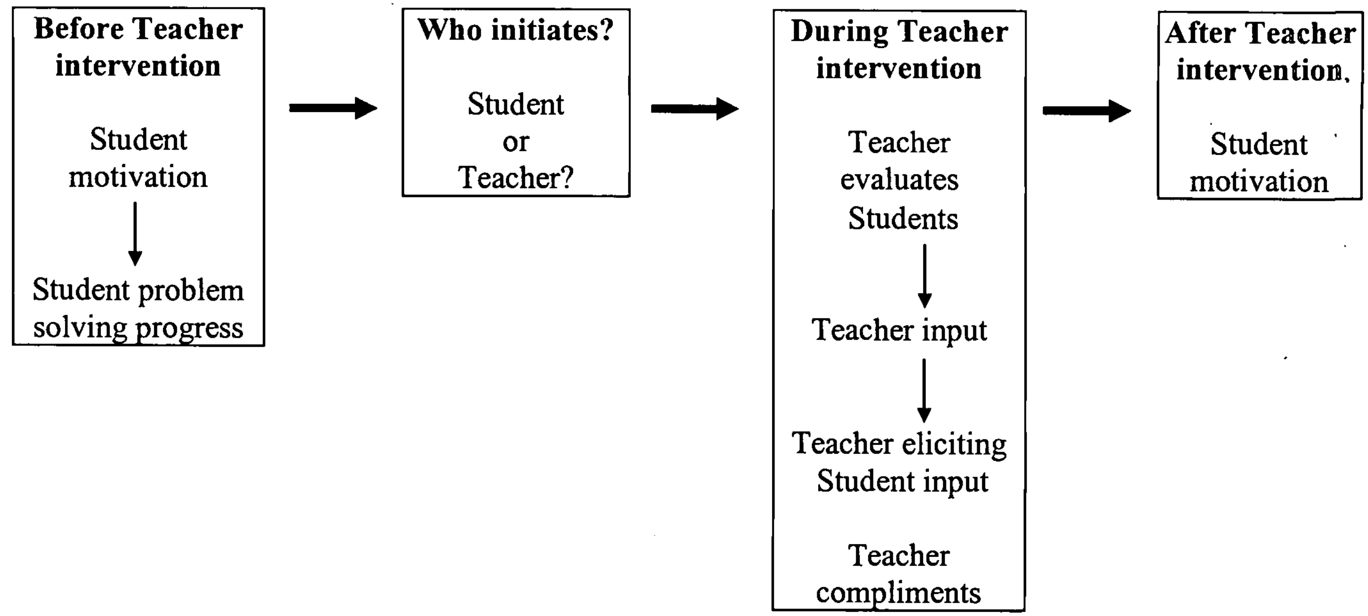
	Total Effect β	Direct Effect β	Variance R^2
S engagement Pre-T	-.19	-.04	.04
S problem solving progress	.11	-.01	.01
T initiates	-.37 **	-.40 ***	.12 **
% T supports	.89 ****	.81 ****	
% T criticizes	.68 ****	.92 ****	.47 ****
Total Words	-.09	-.22	.00
% Words by T	-.29 **	-.22	.04 *
T content	.09	.17	.00
% T questions	.26 *	.41 *	
% T commands	.22	.27	.06 *
% T questions, closed	.23	.22	.03 *
T questions – open before closed	.06	.01	.00
T compliments	.22 *	.22 *	.03 *
Total R^2			.80 ****
Adjusted R^2			.74

Table 5.
Path analysis of variables predicting student engagement after a teacher intervention

	S Problem solving	T initiates	% T Support	% T Criticize	All Words	% T Words	T content	% T question	% T command	% T closed questions	T open then closed questions	T compliment
S motivation	-.12	.17	-.07	.12	.17	.40 ***	.25 *	.31 *	-.33 **	.18	-.16	-.06
Pre- T S Problem solving		-.25 *	.12	-.10	.11	.02	-.02	.25 *	-.24 *	.06	-.15	.02
T initiates			.46 **	-.54 ***	.06	.35 **	-.02	.21	.05	.09	.21	-.03
% T support					.06	-.57 ***	.10	-.14	-.46 **	-.09	-.11	.45 *
% T criticize					.71 ***	-.53 ***	.15	-.16	-.65 ***	-.57 *	-.08	-.12
All words						-.01	.21	.00	.09	.23	.52 **	.03
% T words							.57 ***	-.71 ***	.31 *	.01	.22	-.24
T content								-.26	.17	.01	-.20	-.26
% T question										-.44 *	.20	-.49 *
% T command										-.07	-.18	-.10
% T closed questions											-.28	.14
T open then closed questions												.26
T compliment												

Figures

Figure 1. Temporal and causal relationships in my model of effects on student motivation as a result of a teacher intervention.


Before Teacher intervention
Student motivation
Student problem solving progress
Who initiates?
Student or Teacher?
During Teacher intervention
Teacher evaluates Students
Teacher input
Teacher eliciting Student input
Teacher compliments
After Teacher intervention.
Student motivation

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