2006-1136: PATTERNS IN TEAM COMMUNICATION DURING A SIMULATION GAME

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Patterns in Team Communication during a Simulation Game

Abstract

The development of communication skills is a necessary preparation for effective engineering teamwork. Argyris' "Theory of Action" provides a framework for understanding patterns in team dialogue. Students can benefit from an awareness of these patterns. The theory highlights the detection and correction of errors by sharing information during group collaboration and interactions. Quality decision-making can be enhanced when members of a team develop high degrees of openness and interdependence. Quality decision-making can be diminished when members of a team regulate the information shared within the team. This work analyzes team interactions from simulation games used in an interdisciplinary engineering course as a team training exercise. Communication patterns of the student teams are selected that model effective and ineffective behaviors. Positive and negative excerpts from actual student interactions are discussed as instructional vehicles for student training on teamwork skills and for guiding student understanding of simulation game dynamics.

1.0 Introduction

The ability to successfully work in teams is a crucial ingredient for success in the workplace[1]. Researchers also report that team success in an academic setting is determined more by the group's ability to identify and overcome communication problems, than to handle technical ones [2]. Unfortunately, while universities know their students must understand the complicated technical principles of engineering, it is less common for these institutions to include team communication or team training as part of the undergraduate curriculum. Instructors often give team projects in an effort to help students learn effective teamwork skills, but this practice alone does not teach team dynamics[3]. The fundamentals of how people work and interact is a skill; like calculus or circuits, it must be taught, practiced and evaluated[3,4].

Quality decision-making can be enhanced when members of a team develop high degrees of openness and interdependence. When members of a team regulate or ignore certain information, the quality of the decision is diminished[5]. From the Argyris and Schön "Theory of Action" perspective, "the detection and correction of errors produces learning, whereas the lack of either or both inhibits learning"[6]. Therefore, the ability of a group to learn is paramount for effective decision-making and high team performance. Argyris describes a model of Unilateral Action that most people follow, which leads to reduced valid information and decreased trust. As an alternative, he recommends the Mutual Learning Model as an ideal method for promoting learning and effectiveness while minimizing deception and defensiveness[7].

How can educators provide guidance to students that will help them navigate the complexities of dealing with team dynamics? This paper investigates actual student dialogue expressed through computer simulations and self-reported exercises with the intent to help educators equip students for effective interaction. A simulation game was used in an interdisciplinary class as an instructional tool. Actual student excerpts from the simulation game implementation are used to illustrate patterns in team communications based on Theory of Action concepts. A particularly important pattern is the "Advocate-Illustrate-Inquire" pattern that can be taught as a component and used as an evaluation tool of team communications. The following sections provide additional information on the Theory of Action perspective, a hypothetical example of student interaction, the actual in-class experience in team skills, and an analysis highlighting positive and negative examples in student communication.

2.0 The Theory of Action Perspective

In the most general sense, a theory is a description of the causal link between two variables. Theories range from the common ("April showers bring May flowers") to the complex ("String theory can combine quantum mechanics and gravity"). Certain theories have received intense investigation and validation, such as those that form the basis for a soil mechanics or an electromagnetics class. Other theories have received far less attention, including those that describe deliberate human behavior, which are called "Theories of Action" by Chris Argyris and Donald Schön[8].

Just as engineering theories describe a perceived causal link between variables in a particular context, individual theories of action describe a perceived relationship between actions and anticipated results in a unique setting. All theories of action have the same form: "In situation S, if you want to achieve consequence C, do action A"[8]. Consider the theory of action that is present in a hypothetical example where Joe, a member of a team, struggles with providing honest feedback: "My group really didn't pull their own weight on this last report and I need to let them know that! Mid-semester Team Evaluations are coming up next week; that will be the perfect opportunity to show them the effects of not working as hard as me. I'll rank them low so they start helping out on this project. But, I don't want to let them know I'm upset with their performance because they may rank me lower. I won't mention anything about the quality of their recent work and I'll be extra nice the next time I see them in class." As shown below, this example illustrates Joe's Theory of Action model.

Situation: Other students aren't contributing equally
Intended Consequence: Let the other students know they aren't pulling their own weight so they'll start contributing, but protect own mid-semester evaluation
Action: Rank other students lower, not mention poor work, be "extra nice"

Consider a different hypothetical example in which Sue thinks her other teammates are overzealous: "Ugh! Mike and Carrie are too serious when we work; we'll never enjoy getting this project done. At least this project is similar to the one I did last semester and it's not due for six more weeks. Maybe they'll loosen up and have some fun if I tell them know we don't need to worry about the project until next month."

Situation: Overzealous teammates; similar project already completed; six weeks until the due date
Intended Consequence: Help the other students loosen up, enjoy the project

Action: "Don't worry about this project. It won't be hard and I don't want to even start working on it for a month!"

The accuracy of a person's theory of action often goes unchecked due to factors including time pressures, defensive reasoning, the recognition that the decision is rarely made, or because the theory of action has been used so many times that it causes automatic, unconscious behavior. The potential for automatic, unconscious behavior implies that students will behave in ways of which they are not fully conscious. Argyris terms these behaviors "skilled incompetence" because they have been learned to the point that individuals are unaware of them. For this reason, he differentiates between a person's "espoused theory" (what they say they do) and a person's "theory-in-use" (what they actually do)[8]. To use the example from above, Joe's espoused theory may be "Give fair and honest feedback." However, using his observable actions, we can reasonably say his theory-in-use was actually "Don't give feedback if doing so could cause an undesirable reaction." Likewise, Sue may think she is helping her teammates loosen up and relax, but her "Don't worry…" statement may in fact cause them to become even more concerned because she didn't give them a good reason not to worry!

Argyris and Schön defined two models of theories-in-use, each with their own governing values that determine behavior. The Unilateral Action Model (also called Model I by Argyris and Schön) has the governing values shown in Table 1. Across gender, educational and racial boundaries, most people interact using the Unilateral Action Model as their theory-in-use[8] (pg. xxii). The behavior of the hypothetical Joe and Sue is consistent with the Unilateral Action Model Governing Values, as shown in Table 2.

Table 1: Unilateral Action Model Governing Values

1. Attempt to be in unilateral control over others
2. Strive to win and minimize losing
3. Suppress negative feelings
4. Act in ways that minimize the possibility of being held responsible for making others defensive

Using the Unilateral Action Model does not limit Joe's ability to schedule meetings, Sue's team on deciding which sections to include in the project or the performance of any other type of routine task. However, it does limit Joe's ability to question the other members' level of motivation or degree of contribution to the team. Sue is also prevented from understanding the reasons her group may have for wanting to get started early on the project. In both cases, Joe and Sue act indirectly on unstated, personal perceptions and fail to consider other points of view. Under the conditions propagated by the Unilateral Action Model, difficulty with problem solving about technical or interpersonal issues should be expected[6].

Table 2: Examples of Unilateral Action Behavior

Governing Values	Consistent Unilateral Action Behavior from Joe's Example	Consistent Unilateral Action Behavior from Sue's Example
1	By "being extra nice," Joe is attempting to control the evaluations the teammates will give as opposed to having a candid discussion about team performance	Sue is determined to work according to her own style, telling the team "don't worry" and "I don't want to start for a month."
2	Joe is determined to prove to the others that he is right in believing they haven't contributed enough effort	Sue is determined that the other group members agree to delay working on the project
3	Joe decides against vocalizing the belief that the teammates aren't pulling their weight	Sue covers up that she believes her teammates are uptight
4	Deciding to withhold feedback about recent work minimizes the chance that Joe's teammates will become defensive	Covering this notion up eliminates the chance of Sue's teammates being upset about her evaluation of them.

To address this difficulty, Argyris recommends an alternative, the Mutual Learning Model, which he calls Model II. The Mutual Learning Model is a theory-in-use that produces behavior in accordance with the governing values illustrated in Table 3[9]. The governing values of the Mutual Learning Model are not simply the opposite of the governing values of the Unilateral Action Model, as illustrated in Table 4[9]. For instance, Mutual Learning does not necessarily focus on multilateral control or everyone "winning". It does focus on open decision-making that is based on real and stated data and information.

Table 3: Mutual Learning Model Governing Values

1. Produce valid information
2. Promote informed choice
3. Vigilantly monitor the effectiveness of implemented actions

The benefits of the Mutual Learning Model are what make it difficult to practice; it requires individuals to state their misgivings, concerns and criticisms of team processes openly and honestly while linking them to specific individuals, actions or events. However, this theory-in-use has the possibility of providing students a framework for effective decision making and learning. Consider how Joe's perspective and dialogue would change if he adopted the Mutual Learning Model Governing Values.

1. Joe's beliefs about his teammates' efforts may or may not be based on facts. Assuming they were, Joe producing valid information in this setting may sound like "No one else showed up for our scheduled meeting on Monday" or "Only one person sent me their part of the project by the time we agreed." These statements are easily verifiable and free of blame.

2. In this context, informed choice may take the form of developing a "group contract" for equitable contributions. For instance, team members may agree that missing meetings results in a three-point deduction during team member evaluations. The goal is that people understand the consequences of making decision before they make them, not after.

3. Vigilant monitoring might be assessing whether or not the "group contract" is helping people understand the consequences of their decisions. Perhaps some members of the group scoff at the contract and skip anyway. If so, this would be "valid information" that could spur a discussion about the specific dynamics of the group and what might need to change from Joe's perspective.

Table 4: Comparison of Unilateral Action Behavior and the Opposite of Unilateral Action Behavior

Governing Values for Unilateral Action Model	**Opposite Values of the Unilateral Action Model**
1. Attempt to be in unilateral control over others	1. Everyone is in control
2. Strive to win and minimize losing	2. Everyone wins
3. Suppress negative feelings	3. Feelings are expressed
4. Act in ways that minimize the possibility of being held responsible for making others defensive	4. Act in ways that maximize the possibility of being held responsible for making others defensive.

Consider how Sue might modify her dialogue.

1. "I'm worried that we won't enjoy working on this project together. I know it may look difficult, but I actually did a very similar project last semester. The last project only took a few nights of work; I think this one will be the same."

2. "I'd prefer not to work on this project until next month because I have several other responsibilities with earlier deadlines. Are you opposed to scheduling our first meeting for next month?" This question in turn could elicit a response from her teammates that may indicate why they want to start early: "We both have a several mid-terms and other projects due around the time this project needs to be completed. Plus, we don't have any experience in this area and would feel better about starting early."

3. For the sake of example, let's assume the group decided it was in their best interest to start earlier rather than later. Monitoring the effectiveness of this decision may be important if Sue begins to miss meetings: "Sue, I noticed you've missed two meetings now. Is there something we're doing that's causing you to miss the meetings? Do we need a different time, location, or duration?"

A summary in Table 5 shows the correlation of Joe's and Sue's actions with the Mutual Learning Model.

Table 5: Actions Evaluated in the Context of Mutual Learning Behavior

Governing Values	Consistent Mutual Learning Behavior for Joe's Situation	Consistent Mutual Learning Behavior for Sue's Situation
1	Stating directly observable evidence of other member's actions	Surfaces fears about working with teammates and experience from previous project
2	Cooperatively develop expectations with clear consequences	Both sides state preferences about when to start on the project and their reasoning, with an invitation to disagree
3	Recognizing behavior that is different from what was agreed upon and discussing the consequences	Noticing Sue's absence, despite her agreement, and asking if anything needs to change for her to make the meetings

The Mutual Learning Model includes some basic patterns of dialogue[10]. Probably the most common pattern mentioned in the literature is "Advocate-Illustrate-Inquire," which is rooted in the value of producing valid information[11].

- Advocate a belief or position concerning the decision.
- Illustrate the position with as much specific data as possible.
- Inquire for different perspectives, competing solutions, or agreement.

This pattern helps the speaker state their personal beliefs, explain what led them to believe their position is correct, and check with others for agreement or disagreement. In general, Mutual Learning behavior exhibits much higher levels of illustration and inquiry than the dialogue that occurs in typical team communication[12]. Ordinary conversations typically involve a great deal of advocacy, with remarkably little inquiry into others' reason for a particular decision. Mutual Learning behavior acts to improve understanding by linking relatively abstract thoughts to specific, observable data. Not only does this help teammates understand one another's reasoning, but it also ensure that they have established a common basis for understanding by referring to the same observable data.

3.0 Setting and Simulation

The senior-level/introductory-graduate course "Smart Materials and Sensors" (EE/ME/AE 329 and CE 318) is an interdisciplinary course for electrical, mechanical, aerospace and civil engineers at the University of Missouri – Rolla[13]. During the fall semesters of 2003 and 2005, a business team simulation was run at the beginning of the semester and an engineering team simulation at the end. In the end, six different teams of four students per team completed the two exercises.

The business simulation[14] was a commercially available exercise that involved balancing the budget of a fictitious company. The quantitative measure of performance in this exercise was the amount of profit generated by the new budget. The engineering simulation[15] is one that is currently under development by the authors and was based on creating a new Solar Car for the American Solar Challenge race. The quantitative measure of performance for this exercise was the number of miles that the car would be able to travel per day.

Each simulation was structured with Individual Goal Levels of I, II and III. In general, Level III goals led to individual success while the Level I goals were more helpful for the team and yielded greater quantitative success. The instructions of the simulation were written to encourage the students to achieve the highest Goal Level possible (III) while encouraging the students to achieve the highest possible level of team performance (profit or miles per day).

Students were given "Opening Positions" to use as they started discussion. As time progressed, students experimented with attaining the highest goal possible for themselves while achieving a consensus decision with the rest of the team.

An important point to note is that both simulations were designed with the same premise; sacrificing personal Level III goals for the sake of the team Level I goals will yield a more successful decision for the team. Based on the authors' observations, some students seemed to learn this premise from the first simulation and they sought to formulate a winning strategy in the second simulation by actively questioning other member's specific goals.

The purposes of the games within the course were to serve as a measure of student understanding of team communication concepts and to provide a context to view the team training content of the course. In order to capture the teams' conversations accurately when the simulations were run, the exercises were performed in an internet chat-space and the communications were saved. Some of the dialogue excerpts in this paper are drawn from the actual transcripts from these exercises.

Other excerpts in this paper are drawn from self-reported exercises that students completed in response to differentiated team training[16] delivered as part of the Smart Materials and Sensors course. Half of the students were given Traditional training[17] which covered topics suggested as essential for teams while the others received Mutual Learning training[18].

The first Mutual Learning Model training session illustrated to the students the difference between specific, observable data and higher levels of abstraction that are reflected in everyday thinking. Figure 1 shows an excerpt from the team training.

An individual homework exercise is included as part of the training to reinforce the concepts. Students are encouraged to use conversations from team meetings to help them directly apply the Mutual Learning Model to their team interaction.

Assignment
Write down two or three sentences that people say in a team meeting. It would be most helpful if you select a part of a team meeting that you found especially troublesome or problematic. Underline the directly observable data.

Directly Observable Data	Inferences (attributions, evaluations, and assumptions)
Posture	Goals and Purposes
Movement	Intentions
Expressions	Desires
Color (e.g., red face)	Values
Gestures	Hopes
Sounds (e.g., voice tone)	Personality
Speech Patterns	Thoughts
Silence	Feelings

The following statements use inferences.

a. He was bored and didn't understand me.
b. You're acting nervous about the project.
c. He had a bad attitude and it affected everyone else.
d. She was upset by the decision the team made.
e. It's not standard procedure to implement the design that way.

The underlined portions of the following statements use directly observable data.

a) He was angry, raised his voice, and pounded on the table.
b) Though I read the complicated specification, I didn't understand it.
c) I know she isn't interested in the team because she missed three meetings.
d) He lacked confidence, spoke softly, and mumbled during his presentation.
e) His analysis was sloppy and had a lot of typing errors.

Figure 1. Excerpt from the Team Training

4.0 Examples from Student Dialogue

The following analysis uses actual conversation excerpts from the different simulations. The authors have classified the different patterns according to positive and negative examples in three different categories:

Advocacies, Illustrations, and Inquiries: An investigation of the actual words people use that can affect the quality of decision making
Framing the Situation: An overview of statements and the impact on team effectiveness
Student Reflections: Examples from student interaction that illustrate additional aspects of the Theory of Action perspective

4.1 Advocacies, Illustrations, and Inquiries

The excerpts below indicate information regulation by various members of the teams during both simulations. The statements below delete some specific, observable information that is important for making decisions and also fail to inquire into the perspective of others involved in the decision. The following five excerpts are from different conversations and have been grouped into a category called "naked advocacy" because they violate the Advocate-Illustrate-Inquire approach that promotes quality decision-making:

> *Team Member A: Like I said, 10% is unacceptable.*
> *Team Member B: I must retain my position and $45,000 salary.*
> *Team Member C: Yes, we must start at the motor system.*
> *Team Member D: We should go with a Lead/Acid battery with 5.1 kWh.*
> *Team Member E: Well, if we can balance the budget, goals are more important.*

Each of these statements were made without expressing the assumptions and underlying reasoning that led the speaker to the conclusion. This practice likely led to confusion and misunderstanding among the teammates because the speaker's reasoning was not illustrated. Additionally, none of these statements invite inquiry about the conclusion, a common technique used in an attempt to unilaterally control a decision.

A benefit of practicing Mutual Learning behavior is an understanding of the reasoning that people used to reach a conclusion. Marasigan-Sotto classifies a statement as Mutual Learning if it combines advocacy with either illustration or inquiry[19]. In the example below, Team Member A explains that her reason for "needing" a particular motor is because of his high goal level.

> *Team Member A: I need to buy a DC brushed [motor] because they are … the most efficient for [Goal] Level 3.*

Surfacing this knowledge allows other team members to question Team Member A's motives, since Level III goals are not team-oriented. Had this information not been made public, the overall quality of the final decision may have been jeopardized due to a "personal" goal. The example below illustrates a second way for a statement to be classified as "Mutual Learning."

> *Team Member B: If we really want to win, [Department A] will be the first thing that has to drop in [Goal] Level. Do you agree?*

Team Member B tests his hypothesis with his team by asking if there is agreement. Asking questions is an important way to promote informed choice in the Mutual Learning Model. It should be pointed out, however, that asking disconfirming questions (e.g., "Does anyone disagree?") is more beneficial because it is more likely to draw out differing perspectives from people[18]. Regardless, utilizing inquiry is an important aspect of Mutual Learning behavior.

If the illustration and inquiry were deleted from the two previous examples, the sentences would read, "If we really want to win, Department C will be the first that has to drop in goal level." and "I need to buy a DC brushed motor." The statements in this case are more directive and unilateral than collaborative and mutual.

4.2 Framing the Situation

Students' perceptions are important to how they act. These perceptions, assumptions and other underlying factors construct the "frame" for how a student decides to behave. In the first negative example, a student's frame limited their ability to share information and make a quality decision.

Team Member A: What about the goals?
Team Member B: I think we're supposed to play those close to our chest.

Had Member B been asked why she believed the goals were supposed to be played "close to [the] chest," she may have uncovered that her belief was mere superstition. In fact, if this team had shared their goals, they would have surfaced the formula for team success. The following example involves a situation where members were supposed to state their Level I goals.

Team Member A: Why don't we take everybody to their level one [goal] and see what that gets us.
Team Member A: What are we dropping [Team Member C] to?
Team Member B: What's [C's] lowest?
Team Member C: I would like $40,000 to stay in the company.

Team Member C covers up the truth and states his Level II goal, costing the team an additional $5,000. In this case, the effects of operating with a Unilateral Action mindset hurt the teams overall score. Both of these negative examples exhibit behavior opposed to the Mutual Learning value of "produce valid information."

The positive communication examples in the game simulations are aligned with the governing values of the Mutual Learning Model.

Team Member A: What was the reason again for staying under $13,000? A requirement somewhere?
Team Member B: My level I, Team Member A.
Team Member A: Ok.

This excerpt shows how the group was attempting to produce valid information about the reason for the financial restriction. Whereas previously people had attempted to regulate finances to achieve higher goal levels, Team Member B in this example informs Team Member A the requirement is actually for a lower, team-oriented goal.

Team Member A: You don't have any hidden agendas, do you Team Member B?
Team Member B: No, this time, I don't care. LOL [laugh out loud]

In this example, Team Member A asks Team Member B about their motivations for current behavior. Mutual Learning encourages surfacing underlying goals, whereas a fear of someone operating under the Unilateral Action theory-in-use would be making others defensive.

4.3 Student Reflections

The following examples come from exercises students completed as part of their team training. The first example illustrates the directive nature of a "naked advocacy."

Member A: "Member B, you do the calculations"

Without illustrating the specific reasons that leads A to believe B would do a good job on the calculations and inquiring into whether or not B believes he should do it, the components for disagreement are present. Disagreement is also present in the following example. Despite being involved in the "debate," Member A "acts rationally" to cover up an apparent conflict. The following three individual responses report differently on the same situation.

Team Member A: Actually, I haven't met any conflict in our group.
Team Member B: The conflict that our group confronted when first starting the project was deciding on who was to be in charge of the different positions. The debate was mainly between the other three group members since they all wanted to be either the analysis or calculations person.
Team Member C: A conflict occurred when the team was deciding on who would take what roles in the team project

Illustrating reasoning with specific, observable facts helped the following team have a positive experience.

We have had some discussions on the best way to answer some of our homework problems. Coming from different backgrounds, we have different assumptions going into the problems, and different ways of finding the solution. For example, for a lab exercise, we had to determine the resistance of an unknown element. Member A (one of our Electrical Engineers) had worked the problem differently than Member B and I had (Aerospace Engineer and Civil Engineer, respectively.) Member B and I had assumed one of the known resistor values was 120 ohm, whereas [Member A] assumed it was 350 ohm. To arrive at the correct answer, we had to reconcile how we had each come to our assumption: Member A because it was one of the two most common values for resistors in that application (which he knew from his previous Electrical Engineering classes); Member B and I because we had gone back to the lab and double-checked the value. Once we had each explained our reasoning, we were able to agree on the solution to the problem.

5.0 Assessment, Limitations and Future Research

Measuring the effects of differentiated team training is much more complex than assessing most engineering phenomena. Controlling for the effects of training is difficult since many other factors are involved in team functioning. While the included charts are not statistically significant, they do indicate improved performance among the Mutual Learning teams as compared to the Traditional teams.

Seven measures were used to assess different aspects of team functioning. Each of the measures asked multiple questions to assess the specific aspect of team functioning. The evaluations used a seven-point Likert scale, with higher numbers indicating higher perceptions of the specific measure. All of the students were asked to evaluate a "typical" class at the beginning of the semester ("Pre-Test") and to evaluate the class under study at the end of the semester ("Post-Test"). Four of the scales did not show significant differences between the Mutual Learning and Traditional teams. These four measures were Controlled Regulation, Learning Climate, Competition, and Independence,. The remaining measures, Autonomy, Cooperation, and Constructive Controversy, did indicate differences. The following three charts illustrate the average results for the three Mutual Learning teams and the three Traditional teams (24 students total). The first measure, individual autonomy, assesses the degree to which students were intrinsically motivated to participate in the class[20]. Figure 2 reveals the increase in average autonomy among the Mutual Learning teams.

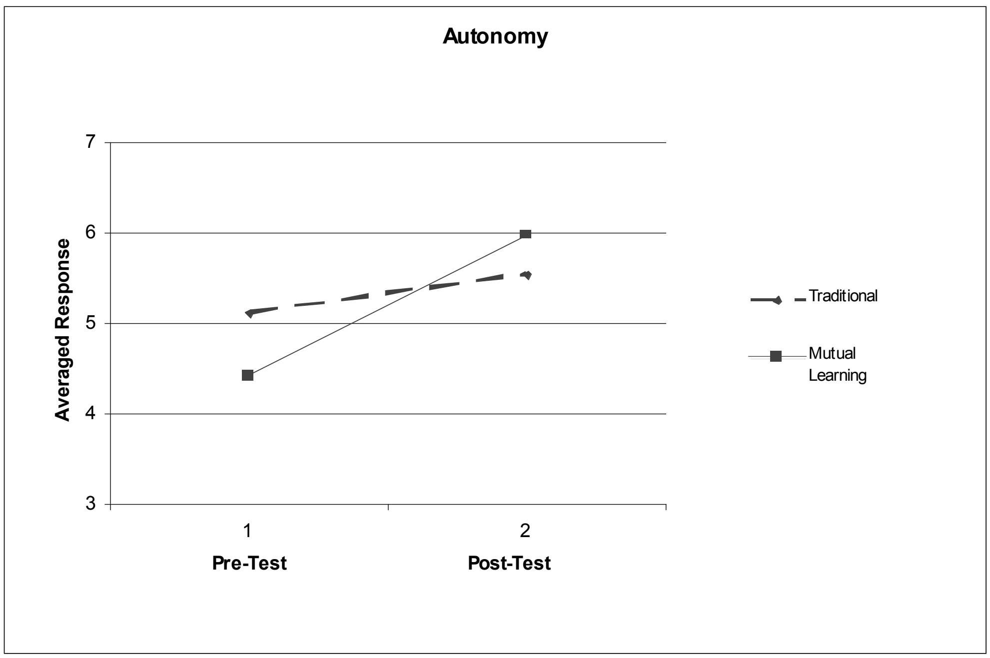

Figure 2. Pre- and Post-Results for Autonomy Measure

To evaluate the effectiveness of team functioning, a measure of goal interdependence was administered[21]. Cooperation is one component of this scale. The teams started with approximately the same level of cooperation, but the cooperation among Mutual Learning teams increased more than the Traditional teams, as shown in Figure 3.

Finally, as an additional evaluation, perceived levels of Constructive Controversy[21] were measured. This instrument provides a measure of how well team members are able to understand opposing positions and integrate diverse ideas. The results of this measure are reported in Figure 4. On average, Mutual Learning teams were better equipped to deal with different positions than the Traditional teams.

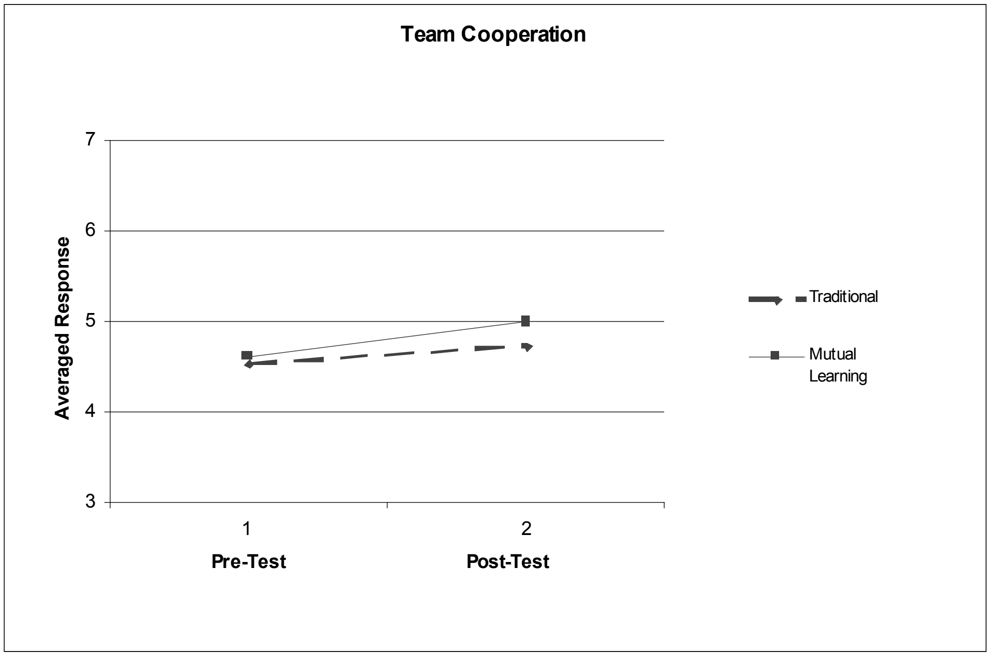

Figure 3. Pre- and Post-Results for Team Cooperation Measure

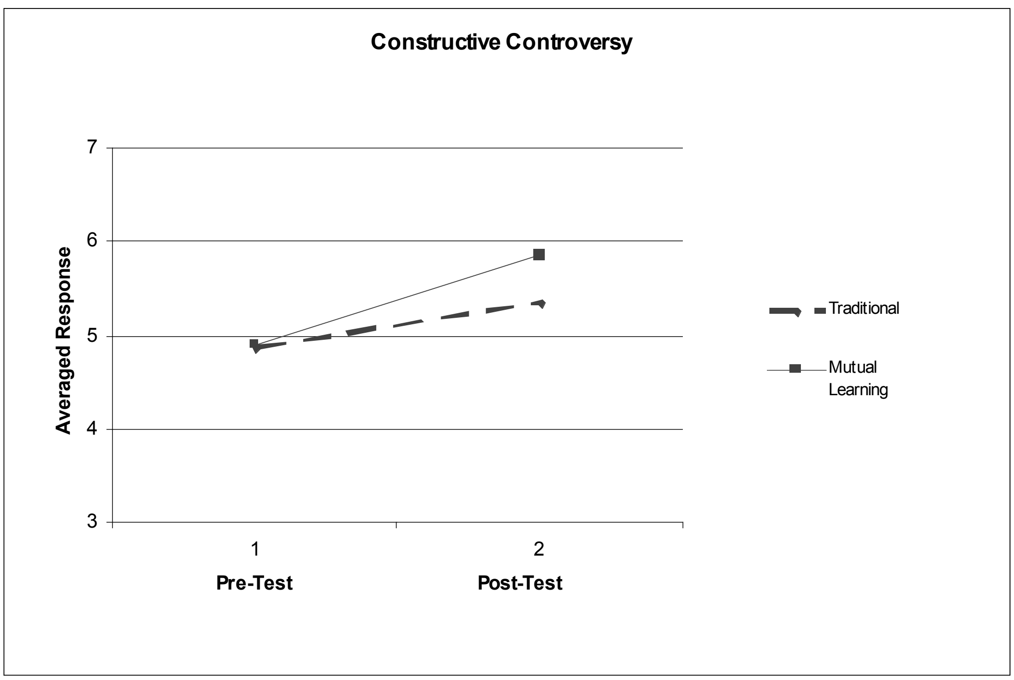

Figure 4. Pre- and Post-Results for Constructive Controversy Measure

The primary limitation to this research is the difficulty of measuring the degree to which students are accurately practicing Mutual Learning. Identifying patterns in simulation conversations is relatively simple. However, assessing the degree to which individuals are implementing Mutual Learning requires time-intensive coding of each line of text. When communication is performed in real-life situations, the conversations must be recorded, transcribed and then coded, increasing the time investment. The authors have already developed and are currently improving a solution to this problem. As people interact face-to-face with each other, microphone headsets, wirelessly connected computers, and voice recognition software create a real-time transcript of the conversation. While simple software has already been successfully implemented, more intelligent computer code is being written to identify Unilateral Action dialogue in these transcripts. When Unilateral Action dialogue is detected, the computer automatically prompts the speaker with a question designed to increase Mutual Learning behavior. The ultimate goal is to provide real-time, Mutual Learning facilitation as voice recognition technology improves.

Another limitation of the research was the goal structures in the Solar Car simulation. During this simulation, the students remembered from the Business simulation that achieving Level I goals would produce a better team victory. Instead of arguing for what was best for their own department, students simply attempted to find working combinations at this Goal Level. This changed the simulation from a mixed-motivation challenge to a "select and check" exercise. Future research could improve the Solar Car simulation in two ways. First, alter the goal structures to appear different from the Business simulation. Second, respond to student concerns of unclear goals by aligning risks and rewards.

6.0 Conclusions and Application

The transition from Unilateral Action to Mutual Learning can be accomplished in the classroom in conjunction with any team project. Like other skills, authentically creating Mutual Learning behavior can be difficult without assistance. An experienced observer may be necessary to effectively interrupt the automatic, unconscious Unilateral Action behavior[10]. While reading may familiarize an individual with Mutual Learning behavior, many people choose to participate in workshops to practice their skills. (More information can be found on the Internet[22] or by contacting the authors.) An instructor can provide formal team instruction or provide informal corrections during team assignments. The Advocate-Illustrate-Inquire communication model is an easy and useful tool for evaluating communication among team members. Examples, such as those from the simulation games, give further reinforcement to the concept and to the consequences.

Students may question the importance of being open and honest, especially if the project has a short-term duration. Regardless of how long students will work in teams, they will develop beliefs and conclusions about other members that will frame how they interact. Making these beliefs public and examining the data and reasoning that led to a particular conclusion will increase trust, openness, and learning, leading to better working relationships and better decisions. Good habits formed during work on student teams will be practiced in the long-term teamwork situations of an engineering career. Effective collaboration and consistent group decisions are more likely when each member of the team operates using the Mutual Learning Model. In the hypothetical examples, Mutual Learning behavior would have produced clear benefits. If Joe had surfaced his fear that his teammates were not going to pull their weight at the first sign of trouble, he would not have to engage in the covert and deceitful behavior. If Sue had openly stated her preferences for scheduling the project and her reasoning, the team would have operated more effectively and the collaboration would have been more productive. In the actual student interactions, Mutual Learning behavior was shown to increase team collaboration and effectiveness in both communication patterns and survey measures.

Success in engineering teams is integrally related to the communication skills the members possess. Team assignments become more valuable if they include significant guidance on effective behaviors. Also, the establishment of poor habits is avoided. The Theory of Action perspective is a useful pedagogical tool for providing students with the guidance to communicate effectively for quality decision-making. Understanding the limitations of the Unilateral Action Model identifies why group dysfunction is not simply "personality clashes;" rather, the problems are ingrained and automatic patterns that seek personal victory and domination. The Mutual Learning Model offers insight into helping groups collaborate as they base decisions on valid information, make informed decisions, and then monitor the effectiveness of the decisions. While teaching and practicing the Mutual Learning Model can be challenging, the benefits to the educational process can be substantial.

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