

## **AC 2010-1446: THE MERIT KIT: METHODS FOR EVALUATING ROLES AND INTERACTIONS IN TEAMS**

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# **The MERIT Kit: Methods for Evaluating Roles and Interactions in Teams**

## **Abstract**

This paper describes the development of a complementary instructional kit designed to support collaborative learning and team problem solving skills. The MERIT kit is developed based on two learning theories (Bandura's social cognitive theory and Vygotsky's social constructivist theory) and a series of prior studies the author conducted with engineering teams in college classroom settings. These prior studies, which employed video and discourse analysis methods, provided evidence for identifying areas where students needed scaffolding.

Due to the constraints in observing all teams when teaching and providing feedback on their processes, a metacognitive structure was used to engage students in self reflection and group processing. The MERIT kit has three key components that are designed to address common challenges we face in teaching and assessing collaborative learning and teaming skills. These three components are: (a) "Vicarious Learning Experiences" using case study videos (e.g., PBS Design Squad clips) along with group processing with MERIT cards, (b) the "I Know My Team Members" document, and (c) a "Performance Assessment Task" used for pre and post evaluation. Next steps, in the validation of the MERIT kit, is wide dissemination and evaluation of the kit in supporting individual student learning.

## **Factors that Motivated the Development of the MERIT Kit**

Today, more than 50% of science and engineering faculty require their undergraduate students to participate in collaborative group projects (National Science Board, 2008). Current trends suggest that this percentage will increase (Project Kaleidoscope, 2006). The results of research on the impact of cooperative and collaborative learning methods on student learning at the undergraduate level are also promising. Hake's (1998) study involving six-thousand students provides robust evidence that interactive teaching methods involving group work are more effective than traditional teaching methods. In addition, ABET requires that all accredited engineering programs demonstrate student attainment of outcomes related to design, problem solving, and teaming. For instance, the engineering accreditation Criterion 3 (ABET, 2005) specifically addresses teaming: "an ability to *function on multi-disciplinary teams* (criterion 3d)." Recent National Academy of Engineering reports (NAE, 2004; NAE, 2005) also recognize the growing need for teaming skills to solve increasingly complex problems in a global context.

Small-group learning strategies are effective in creating positive attitudes towards learning and increased persistence in STEM courses (Springer, Stanne, and Donovan, 1999). However, despite the historical literature-base on cooperative learning (Johnson Johnson, & Holubec, 1998), educators still strive for answers to questions such as: How can I scaffold group learning? How can I teach teaming skills to my students? What criteria should I use to build effective teams? *Despite the importance of gaining effective teaming skills for our students and the increased popularity of using collaborative learning methods in college classrooms, there are limited modules and instructional tools designed to teach teaming skills to engineering students.*

There are indeed no comprehensive teaming kits that provide ready to use materials for the instructors and the students, tips on how to adopt these materials to meet specific classroom constraints, examples of common student responses and how these responses reflect learning and challenges, and data on how and why the kit addresses certain student learning objectives.

Although the use of collaborative, cooperative, and team-based teaching methods is not a new concept, educational research in engineering is still in its infancy in terms of teaching and assessing skills, such as the ability to function in multidisciplinary teams (Shuman et al., 2005). What we know about teams is that a team is not only a group of individuals assembled to reach a common goal but it is also a social entity that engages in complex interactions. There is a need for a kit that truly addresses students' challenges and needs.

In the context of a classroom, the features such as equality and mutuality do not occur naturally just by bringing people together to solve a common problem. This is because students come to class with their diverse content knowledge, engineering skills, and teaming experiences. How do students utilize such diversity and solve problems collaboratively and effectively? Prior research shows the weaknesses of engineering student teams lay in two key areas (Roberts, Yaşar-Purzer, Morrell, Henderson, Danielson, & Cooke (2007). First, student teams have difficulty defining their goals and the design problem and fail to monitor their own progress. Second, teams commonly make decisions based on opinions, and do not gather external information or engage in rich discussions of data and evidence. The video-based study conducted by the author also showed that first-year engineering student teams engage in four types of actions when solving design problems: goal, relationship, learning, and challenge actions (Purzer, 2009). These actions are described in Figure 1.

I started developing the MERIT project with a vision of engineering student teams that can work in multidisciplinary and multicultural teams and consequently design innovative solutions to complex and global problems. While there are effective teaming modules available to be used by higher education faculty to manage student teamwork (e.g., BESTTEAMS and Team Developer) there are no comprehensive curriculum materials that are specifically designed to support individual student learning and collaborative learning skills with a focus on increasing the involvement and academic self-efficacy of underrepresented groups. MERIT is a comprehensive teaming kit that can be used in any engineering classroom setting as a complementary curriculum material.

### **Current Instructional Methods and Tools**

Teaming is an essential component of engineering design and problem solving. Currently, there are well-written books and curriculum materials that address teaming skill development such as the *Team Developer* (McGourty and DeMeuse, 2000), *Team-based Learning* (Mickelson, Bauman-Knight, & Fink, 2004), *Teamwork and Project Management* (Smith & Imbrie, 2004), *BESTEAMS* (Schmidt, Schmidt, Smith, Bigio, & Bayer-Contardo, 2005), and *CATME* (Ohland, Pomeranz, & Feinstein, 2006). These books and modules have many strengths. For example, the BESTEAMS module is designed to guide engineering faculty in supporting student team effectiveness and management and provides a series of nine learning modules that can be delivered in 50 – 90 minute sections. CATME is a system available to faculty via Internet and

enables the design of teams and evaluation of team effectiveness. The book by Smith and Imbrie (2004) presents useful guidelines such as how to run a meeting and how to manage team conflicts. They provide instructors with instructional tools such as peer evaluations and grading strategies that promoted individual accountability (Imbrie, Maller, and Immekus, 2005; Ohland, Layton, Loughry, & Yuhasz, 2005).

The MERIT kit adopted strategies from the previously tested methods and instruments but also addresses some of the gaps. For example, according to Johnson, Johnson and Holubec (1998), there are five basic elements that are critical for effective collaboration: goal setting; goal interdependence; face-to-face interactions; individual accountability; and time for group processing. Among these elements and essential component, group processing, is missing in both the instructional modules and student team interactions. In the prototype MERIT kit, video clips and design tasks accompanied by group processing activities support group processing.

### **Theoretical Framework that Guided the Kit Design**

We have limited knowledge of how teams learn. To understand how students learn how to work in a team and to increase the potential of team-based learning for promoting student learning and engagement, the MERIT curriculum is designed based on: A) learning theories, and B) the needs of engineering students identified through qualitative research, and C) a focus on underrepresented groups and promoting an equitable participation of all students in team tasks.

A key characteristic that distinguishes the MERIT curriculum from other teaming modules is that it is built on learning theories such as the “how people learn” framework (Bransford & Donovan, 2005), social cognitive theory (Bandura, 1997), as well as social constructivist and scientific argumentation theories (Erduran & Jimenez-Aleixandre, 2008).

Through the MERIT curriculum, students will be asked to engage in group processing and reflective practice. Reflective practice is commonly a key behavior of expert problem solvers (Chi, Glaser, & Farr, 1988). Engaging in reflective practice will reinforce student team relationships, goal attainment, and design processes. Another framework that guides the design of the curriculum is Albert Bandura’s social cognitive theory. This theory states that mastery experiences (first-hand experiences) are not the only form of learning. People can also learn through vicarious experiences and observing others completing a task. The MERIT kit promotes learning through both mastery and vicarious experiences. In other words, students will be provided with vicarious and apprenticeship activities where they will observe other teams and learn from their team interactions. But students will also have opportunities to practice these skills. Traditionally students are expected to learn teaming skills through first-hand experiences; however, very often these experiences do not result in fruitful interactions. Using scaffolding through vicarious activities and reflective practice are essential in increasing students’ mastery experiences during teamwork. The MERIT curriculum will also promote learning of engineering concepts and skills (in addition to teaming skills) by inducing positive interdependence within student team interactions. In addition, students will be guided on how to engage in challenge actions and scientific argumentation (i.e., asking for data and evidence) that are essential for effective decision making as well as learning (Purzer, 2009).

## Research on the Needs of Engineering Students

I have conducted several studies on student design teams and characterized first-year engineering students' challenges in solving design problems when working in teams. The research methods of the initial study were based on the methods and the design categories used by Atman, Cardella, and Robin (2005) and used verbal protocol analysis to describe students' approaches. The preliminary findings indicate that students spent most of their time on *modeling* (30%), followed by *information gathering* (17%) and *idea generation* (15%). A follow-up study looking at student team interactions, showed that engineering teams simultaneously engaged in four types of actions: goal actions, relationship actions, learning actions, and challenge actions (Purzer, 2009). The next step was identifying the theoretical frameworks that explain how student discourse actions can support individual student learning, teaming skills, and design processes. *This is important because if we define the learning theories that relate to student actions we can develop effective scaffolding activities that will support student learning.*

The first interaction category involves **goal actions**. The support for this category comes from cooperative learning theories (Johnson, Johnson, & Smith, 1991) and "how people learn" literature (Bransford, & Donovan, 2005) that describe goal-setting and self-monitoring as critical components of learning. Examples of goal-oriented actions are clarifying assignments, monitoring time, and suggesting a project plan. The second category is **relationship actions**. This category is driven by the social cognitive theory indicating that supportive social interactions and persuasions can affect behaviors and achievement through the mediation of self-efficacy (Bandura, 1997). Examples of relationship-oriented actions include acknowledging group members' contributions and asking for others' comments. The importance of this category for the interactions of first-year engineering students is established by previous research with the finding that engaging in supportive discourse is positively correlated with self-efficacy (Yasar-Purzer, Baker, Roberts, Krause, 2008). The third interaction category includes **learning actions**. This category is based on the social constructivist theory and utilized to promote learning during team discussions (Vygotsky, 1978). Finally, the **challenge actions** urge students to gather data and evidence and make decisions based on reliable information. The theoretical framework that supports the use of challenge actions comes from the science education literature on the importance of student scientific argumentation on student knowledge building (Erduran & Jimenez-Aleixandre, 2008).

## Components of the MERIT Kit

In the light of the studies conducted and the theories of student learning, the MERIT kit was developed. Examples of the kit items are provided in the Appendix. Full materials can be accessed at <http://web.ics.purdue.edu/~spurzer> or by contacting the author.

## *Learning through Vicarious Experiences & Reflection*

For a teaming kit to be effective, it should be taught in the context of a real team task. I was interested in teaching not only through mastery (first-hand) experiences but also through vicarious experiences where students have opportunities to watch other teams and learn from their strengths and mistakes. For this, I reviewed various television and radio programs that

model the interactions of engineering teams (e.g., ABC’s Nightline program on IDEO designers, Discovery Channel’s Mythbusters, NPR’s Car Talk, PBS’ Design Squad, etc.). I evaluated these programs with regard to our learning objectives and consequently selected an episode from the Design Squad program for students to view and reflect on. Student and teacher materials were developed to accompany the video clip and facilitate student group processing.

### ***Selection of a Globally-Oriented and Socially-Relevant Team Design Task***

The episode was selected from the Design Squad involved a challenge asking teams to design a peanut butter maker for women in Haiti (clips can be viewed at <http://pbskids.org/designsquad/challenges/s1-ep6.html>). This challenge involves a real, contemporary, and critical engineering problem. Second, the problem is global and challenging but at the same time, it is simple enough to be tackled by first-year engineering students. In addition, the problem promotes engineering skills requiring the ability “to deal with complex interrelationships that include not only traditional engineering problems but also encompass human and environmental factors as major components.” (National Science Board, 2007, p.2)

### ***Team Processing***

Teams will have ample opportunities to engage in goal processing and reflecting on how effective their team actions are. Figure 1 shows the descriptions of team actions that are used to promote group processing. Using these actions, an instrument called a MERIT card was developed. This card has the dimensions of a bookmark. The questions included in this MERIT card are carefully selected to address the weaknesses of the student teams revealed by our prior research as well as teaching experiences. Instructors can direct students to use the MERIT cards and reflect on their teaming processes anytime during a team project.

#### **A. Sharing Goals, Knowing Team Members**

An instrument called “I know my team members,” developed to be used at a later stage after students have some opportunity to get to know each other’s strengths. The purpose of this activity is to give students opportunities to state the strengths of their teammates as well as their own goals and discuss how the members of the team can help each other meet individual goals. These instruments also reinforce positive interdependence and individual accountability as students learn about each other’s goals and motivations.

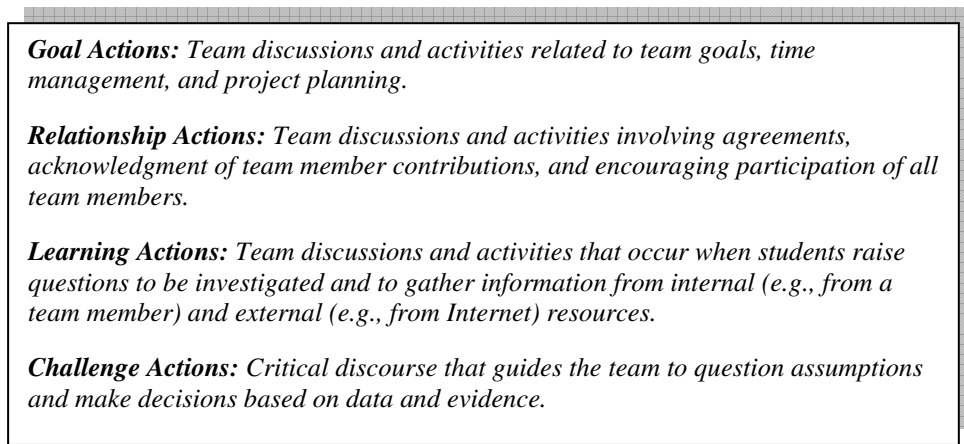


Figure 1. Team Actions used in the MERIT cards

## Methods and Procedures

The following order is used when implementing the kit materials. This order and the number of activities can be modified depending on the time available and the structure of the course.

1. **Pre-test Content:** Assess students' prior content knowledge
2. **Pre-Design:** Present Design Squad challenge & have student develop a plan to tackle this challenge (teams submit their processes and solutions)
3. **Vicarious Experience & Group Processing:** Watch Design Squad clips & evaluate their processes
4. **Mastery Experience & Group Processing:** Provide a course project challenge & embed team processing activities & goal setting
5. **Post-Design:** Have students re-tackle the Design Squad Challenge
6. **Post-test Content:** Re-assess student content knowledge

A comparison of pre- and post-test measuring content knowledge would provide instructors with information on individual student learning. A comparison of the pre-and post-design documentation provides both faculty and students with information on their design skills.

As part of the group processing, teams are asked to answer eight questions provided in Table 1 using 4 point scale (0=never occurred, 2=somewhat occurred, 4=exemplary)

Table 1. Group Processing Questions

Action	Question
Goal Actions	<i>Did the team establish a common understanding of the goals in the beginning and refer back to goals for clarification during the meeting?</i> 0 1 2 3 4
	<i>Did the team establish a timeline in the beginning, track the time, and make process adjustments when necessary?</i> 0 1 2 3 4
Relationship Actions	<i>Did everyone have a fair opportunity to participate and were everyone's ideas considered?</i> 0 1 2 3 4
	<i>Did the team acknowledge contributions, hard work, and good ideas, and show gratitude towards each other?</i> 0 1 2 3 4
Learning Actions	<i>Did the team develop new understandings through discussions of new information obtained from each other and external resources?</i> 0 1 2 3 4
	<i>Did the team use visual representations (pictures, charts, models) and examples to communicate ideas to each other?</i> 0 1 2 3 4
Challenge Actions	<i>Did the team identify possible challenges and discuss how they can be tackled?</i> 0 1 2 3 4
	<i>Did the team make decisions based on data, evidence, calculations, and a systematic evaluation rather than opinions?</i> 0 1 2 3 4

## Results

The kit was successful in raising students' awareness about their processes. Figure 2 shows data on students' responses on how well they engaged in key team actions after they solved a 20-minute long design challenge (Please see Table 1 for the specific questions students answered). As the figure shows student perceptions of their weaknesses (e.g., time management, and information gathering) was aligned with our prior studies.

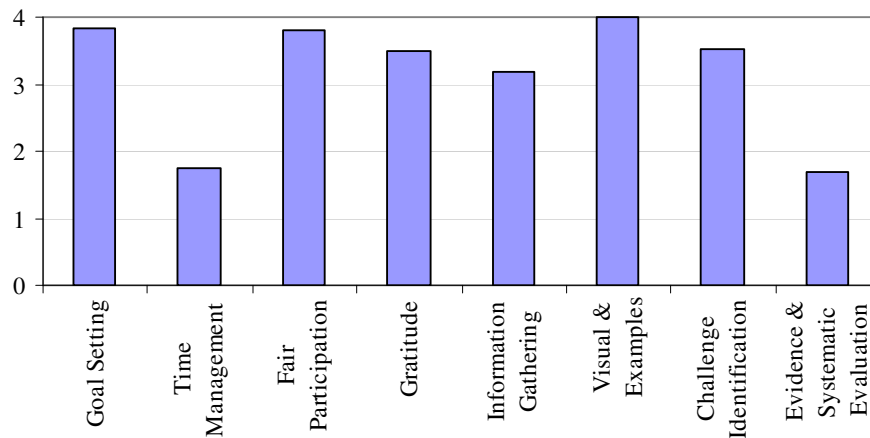


Figure 2. Student Reflection on How Much They Engaged in Key Teaming Actions

## Future Research

A series of in-depth studies were conducted to identify how teams learn and to guide the development of the MERIT kit. Hence, the kit has a strong theoretical and research foundation. The kit addresses an important need for instructional tools and methods that can support student learning when working in teams. Despite these strengths, further research is needed to determine the impact of the MERIT kit in supporting individual student learning.

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## Appendix

### I Know My Team Members

Include both technical strengths and teaming strengths

\_\_\_\_\_ is good at

- 1)
- 2)
- 3)
- 4)

\_\_\_\_\_ is good at

- 1)
- 2)
- 3)
- 4)

\_\_\_\_\_ is good at

- 1)
- 2)
- 3)
- 4)

\_\_\_\_\_ is good at

- 1)
- 2)
- 3)
- 4)

To assure that my team succeeds, I (\_\_\_\_\_) should be/do more ...

- 1)
- 2)
- 3)
- 4)

Suggest a team name:

## Team Interactions in Engineering Design

### G.R.L.C. Model

Goal  
Actions

- Did the team establish a common understanding of the goals in the beginning and refer back to goals for clarification during the meeting?

- Did the team establish a timeline in the beginning, track the time, and make process adjustments when necessary?

Relationship  
Actions

- Did everyone have a fair opportunity to participate and were everyone's ideas considered?

- Did the team acknowledge contributions, hard work, and good ideas, and show gratitude towards each other?

Learning  
Actions

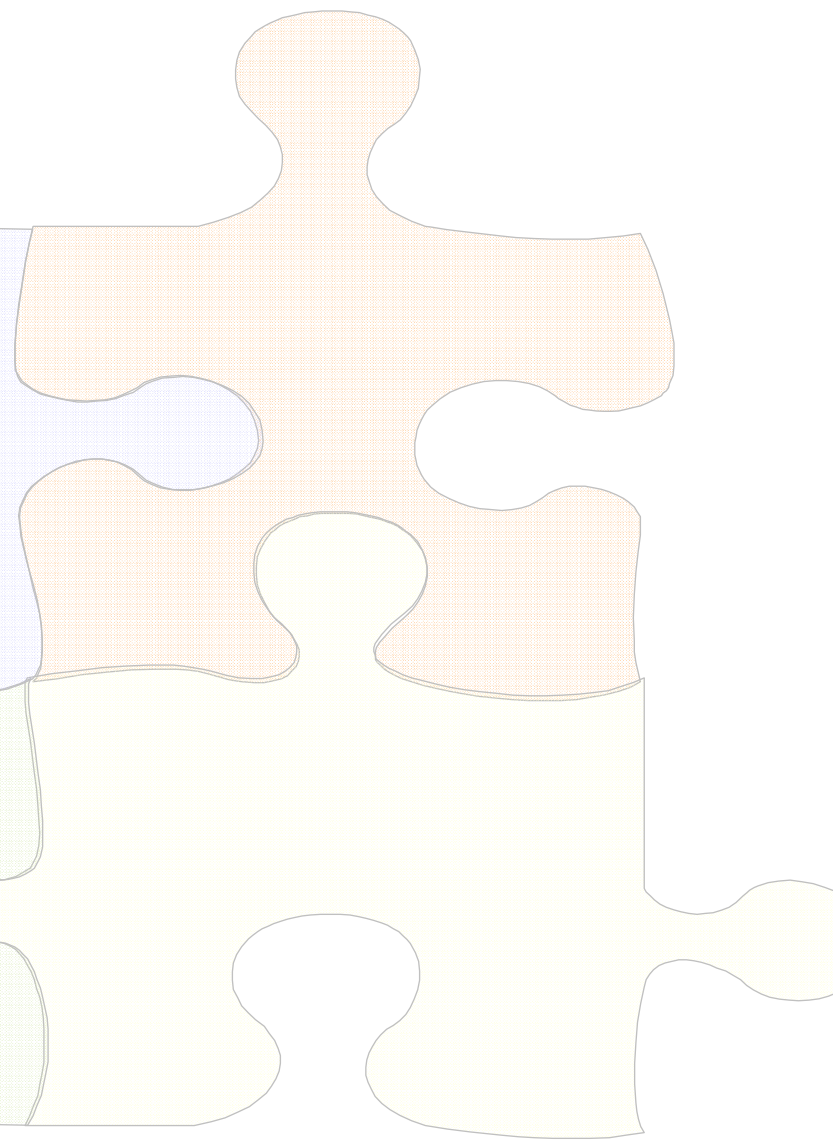
- Did the team develop new understandings through discussions of new information obtained from each other and external resources?

- Did the team use visual representations (pictures, charts, models) and examples to communicate ideas to each other?

Challenge  
Actions

- Did the team identify possible challenges and discuss how they can be tackled?

- Did the team make decisions based on data, evidence, calculations, and a systematic evaluation rather than opinions?



Evaluation of Team Interaction  
 Design Squad: Peanut Butter Maker for Haiti

<http://pbskids.org/designsquad/challenges/s1-ep6.html>

**BLUE Team (Auger Bit Concept):** Noah, Krishana, Michael, Natasha

**RED Team (Flower Pot Concept):** Tom, Giselle, Kim, Joey

\*\* Observe both team's problem-solving processes and team interactions\*\*



	Blue Team (Auger Bit)		Red Team (Flower Pot)	
	Strengths	Weaknesses	Strengths	Weaknesses
<b>Brainstorming</b>				
<b>Design</b>				
<b>Build</b>				
<b>Test</b>				

What was missing in both teams?

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