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Help! I've Been Asked to Mentor a Robotics Team

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Mentoring a robotics team can teach you how to incorporate engineering principles into your science curriculum, as called for in the Next Generation Science Standards (NGSS), by allowing you to engage in engineering design experiences and increase your comfort with these activities. Bringing engineering into science classrooms takes time and practice, and science teachers with no engineering experience can find it challenging to integrate engineering design into the science curriculum in a way that maintains connections between engineering design and science content (Cunningham and Carlsen 2014; Dare, Ellis, and Roehrig 2014).

Robotics team mentors serve as facilitators who guide and support students through the problem-solving process. They encourage students to reflect on and learn from failures and to understand that there is more than one way to solve a problem. Students’ successes are influenced by a mentor’s ability to motivate individuals and create an environment in which stu-
students feel valued and learn to function as part of a team. Consequently, mentors face a range of challenges, from forming and managing teams to helping students maintain motivation and interest.

In a recent National Science Foundation Innovative Technology Experiences for Students and Teachers–funded project, researchers used a combination of online modules, interactive webinars, and face-to-face sessions to prepare middle school teachers to address the challenges of mentoring robotics teams. The project focused on mentors and participants in Botball, a team-oriented, educational robotics program (see Resources). Mentors participated in one of three mentor training experiences: mentoring for best practices, mentoring for STEM (science, technology, engineering, and mathematics) self-efficacy, or a combination of best practices and STEM self-efficacy. Mentor training occurred prior to technical robotics training, with the best practices and self-efficacy groups receiving 17 hours and combination groups receiving 20 hours of professional development.

Based on the study, we offer recommended mentoring strategies for teachers new to coaching robotics teams. The strategies appear in two sections, best practices and promoting self-efficacy.

### Best practices model and mentoring strategies

The mentor training used the Tuckman and Jensen (1977) expansion of Tuckman’s (1965) stages of small-group development as the framework for forming effective teams. This framework (Figure 1) involves five stages—forming, storming, norming, performing, and adjourning—which relate to both relationship-building and task completion. Not all teams go through these stages linearly. For example, if a team encounters a new challenge, it might cycle back to the storming stage. Not all teams make it through all the stages to become highly functioning teams.

#### FIGURE 1: Stages of team development [Tuckman and Jensen 1977]

<table>
<thead>
<tr>
<th>Forming</th>
<th>Storming</th>
<th>Performing</th>
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**Forming**

In this first stage, team members become acquainted with each other, the project, and the equipment they will be using. They learn the project’s goals and discuss the possible roles they will play on the team. Team-building exercises that help students become acquainted with one another’s interests and strengths and promote functioning as a team are useful in this stage.

Our recommendations are:

1. **Encourage students to identify their interests and strengths.** For example, have students write application letters explaining why they want to be on the team and what they might contribute.

2. **Engage students in team-building activities.** Creating a team motto and logo is one example of such an activity.

**Storming**

During this stage, students struggle to get themselves and their ideas recognized. This stage is frequently characterized by division and conflict. This is good a time to review and revise ground rules, while stressing listening and conflict-resolution skills.

Our recommendations are:

1. **Enlist student help in setting rules for behavior and engagement.** Work collaboratively with students to
set and revise team rules and goals.

2. **Introduce strategies that encourage listening and respectful discussion.**
   Implement strategies such as having one student summarize another student’s main point in a discussion or using a “talking stick” to allow each student time to speak. A **talking stick** is an object passed among members of a group to ensure that each member has time to talk. Only the member possessing the object at any given time is allowed to speak.

**Norming**
During the third stage, team members begin to work together and recognize and appreciate each other’s roles. They begin to trust each other and production increases.

Our recommendations are:

1. **Engage students in setting goals and reporting progress.** Begin each session with a team meeting and have students lead these meetings to allow the team to become more autonomous and self-directed.

2. **Create a relaxed atmosphere that encourages risk-taking and experimentation.** Regularly ask students about their work, provide encouragement when they are struggling, promote learning from failures, and celebrate successes.

**Performing**
At this stage, the team is functioning well and working without conflict. Team members collaborate and work to accomplish team goals.

Our recommendations for this stage are:

1. **Engage all students in project milestones.** Each member of the team should participate whenever the robots and programs are tested, celebrate successes, and offer suggestions when testing fails.

2. **Encourage understanding of all roles.** Although most teachers encourage students to self-group into programmers, builders, and writers or presenters, incorporate activities to make sure all students understand each of the roles.

**Adjourning**
During this final stage, team activities conclude. The team has participated in the competition. It is now time to reflect on what the team and each participant have accomplished and to evaluate and celebrate the experience.

Our recommendations are:

1. **Include opportunities for reflection.** Following the robotics competition, consider creating a document containing reflections and suggestions for future teams.

2. **Provide opportunities for celebration and closure.** Consider demonstrating the robots in school assemblies or provide closure with a team party.

**Self-efficacy model and mentoring strategies**

Bandura (1977) defines self-efficacy as a belief in one’s ability to organize and achieve a specific goal. Self-efficacy is task-specific and a predictor of an individual’s motivation and effort to complete a task. Self-efficacy influences students’ performance in the classroom and during extracurricular activities.

The four main sources contributing to the strength of a student’s self-efficacy beliefs are: mastery experiences, vicarious experiences, social persuasion, and physiological state (Figure 2). The following section includes a brief description of each of the four sources of self-efficacy, followed by examples of mentoring strategies that encourage strong and positive student STEM self-efficacy.

**Mastery experiences**
How individuals interpret previous experience performing a task influences how they believe they will be able to perform related tasks in the future. Successful experiences can lead to an increase in self-efficacy, whereas failure on a related task can weaken self-efficacy and transfer to other experiences.
Our recommendations are:

1. **Provide opportunities for hands-on practice with a task or skill before attempting to complete the task.**
   Give students the opportunity to explore robotics-related component parts and build simple robots before beginning to design robots for the competition.

2. **Create a safe environment where students do not feel threatened if they fail at a task, but instead are encouraged to try the task again.**
   Create a culture in which team members encourage and assist each other in moving on from failure.

**Vicarious experiences**
Learning about a task by watching others complete it successfully can increase individuals’ belief that they can also perform that task. Seeing a person like oneself model a task provides the greatest effect on self-efficacy. For example, observing a female peer successfully build a robot can increase another female student’s belief about her competence to build a robot.

Our recommendations are:

1. **Visit a facility where students can observe a similar task performed.** If possible, visit an industrial facility that uses robots and have students apply what they learn when constructing their own robots.

2. **Encourage peers to model a process or task.** Consider inviting high school robotics club members to your team meetings or have students share their knowledge about robot construction.

**Social persuasion**
Social persuasion involves receiving feedback, judgment, and support from others. Social persuasion influences self-efficacy when feedback is combined with mastery experiences. Such persuasion is more effective in influencing self-efficacy when it comes from significant individuals such as teachers or parents, particularly when feedback is constructive, honest, and relates to the student’s past performance, interests, and actual abilities.

Our recommendations are:

1. **Combine a mastery experience with feedback that focuses on the task and attainable goals.** Provide feedback to individual students that recognizes improvements in performance and offers suggestions for further improvements.

2. **Invite professionals to be part of a mentoring team that provides feedback to students.**
   Invite an engineer to talk with

**FIGURE 2: Self-efficacy model [Bandura 1977]**

![Self-efficacy model](image_url)
team members about his or her experience with robotics and provide feedback on the team’s progress.

Physiological and affective states

Factors such as stress levels and emotions influence how individuals react to a task. Students who are nervous about performing a task might begin to doubt their abilities, resulting in an unfavorable effect on both performance and self-efficacy. On the other hand, students who aren’t anxious about performing a task are more likely to approach the task with excitement, resulting in greater self-efficacy.

Our recommendations are:

1. Provide background music or videos to help student relax as they work.
2. Encourage short breaks involving physical activity during work sessions. Allow students to take stretching breaks and short walks around the building when they find themselves becoming stressed or frustrated.

Conclusion

The experience of mentoring a robotics team can be challenging to a new mentor; however, mentoring provides benefits to teachers, especially those with no previous experience with robotics or engineering design. The experience of coaching a robotics team provides a mastery experience to improve teachers’ self-efficacy with engineering concepts and design. Research shows that increased familiarity with engineering design increases not only teachers’ engineering content self-efficacy, but also their self-efficacy in teaching engineering (Hammack and Ivey 2017). Teachers in our study who initially felt unprepared described how the experience of mentoring the team increased their confidence in working with teams and engineering design. As one teacher noted, “I felt intimidated and uncomfortable at the beginning. I didn’t know anything about robotics or working with robotics kits. I struggled at first, but I learned a lot in the process.”

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RESOURCES

Botball—www.botball.org


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