# Comprehensive STEM Education and Teaming (CSET): An Innovative Approach for Change

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**Abstract:** Comprehensive STEM Education and Teaming (CSET) is a practical, research-driven methodology that supports interdisciplinary teaching and learning. It establishes a foundational approach to Integrative STEM Education by unifying STEM concepts within project-based settings that empower students with practical abilities needed for retention and success. The teaming approach draws from management frameworks such as Lean Six Sigma and Agile to bolster collaboration, communication, and leadership in classroom settings. CSET encourages educators to connect ideas across disciplines and link them to real world problems. This approach supports the student's capabilities to develop confidence, critical thinking, and teamwork aligned with today's STEM workforce.

**Keywords:** STEM, Project-Based, Teaming

## Introduction

As the term "STEM" is now mainstream in our society and particularly in educational domains, the pedagogical foundations of teaching STEM are absent. The individual components of science and mathematics education are well founded within educational curricular silos, but the "technology and engineering" aspects still have the stigma of educational ambiguity. This assertion is nothing new to the profession of technology and engineering education. Much has been written about the "how" and "whys" this occurs, but as bona fide educators dedicated to technology and engineering education, there still is an identified deficiency that does not appear to be alleviated soon. Comprehensive STEM education through the process of teaming could change how educators of all disciplines can improve their teaching and evolve as educators, in addition to creating relevant STEM visibility within their institutions abating the silos prevalent in non-elective, core subject area

## Comprehensive STEM Education

In his groundbreaking article, Sanders (2008) makes a seminal argument to infuse a new educational STEM paradigm into all educational entities. This was the introduction of "integrative" STEM education. "Our notion of integrative STEM education includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p. 21). This notion was well received throughout the teacher education community. Many educational bodies, including the International Technology and Engineering Educators Association (ITEEA), the National Science Teaching Association (NSTA), and the National Council of Teachers of Mathematics (NCTM), have all embraced this pedagogical approach. In addition to educational organizations, many government entities have infused the notion of integrative STEM into their educational endeavors. Federal and state departments of education, the National Aeronautics and Space Administration (NASA), and the National Science and Technology Council (NSTC) have all advocated integrative STEM as a viable means to educate students about STEM.

Comprehensive STEM education takes integrative STEM further. It incorporates all four disciplines into specific projects at the teacher's discretion (White, 2014). For technology and engineering teachers, it incorporates the STEM interconnectedness inherent in almost every project a technology and engineering teacher already does and can be aligned with state and national standards. Comprehensive STEM Education methods can produce innovative proficiencies for transdisciplinary teachers within STEM disciplines and those who are not. This type of activity is traditionally done within a technology and engineering class or course; however, it can be utilized in most classrooms regardless of the discipline.

Research indicates that science, mathematics, and elementary educators in K-12 school systems find implementing any conceptual STEM methods (comprehensive or integrative) challenging because they feel they are not adequately prepared (Shernoff, et al., 2017). However, research also indicates that through proficient training methods, these STEM methods can be achieved and successful in K-12 schools both nationally and globally (Shernoff, et al., 2017; ITEEA, 2018; Kang, 2019). It is reasonable to assume that other disciplines (social sciences, language arts, physical education, music education) also feel challenged if asked to infuse some type of STEM learning into their curricula. Therefore, this methodology has multidisciplinary aspects and an all-encompassing approach to teaching and learning in STEM that all disciplines can utilize.

In educational settings, non-STEM core disciplines are often in "educational silos", and STEM-related activities are often not part of the curriculum. "The full integration of engineering, technology, science, and mathematics is in tension with the more traditional separation of disciplinary content learning in schools." (Shirley, 2018, p. 170). By using the Comprehensive STEM Education and Teaming (CSET) methodology, silos can be alleviated. An inclusive, comprehensive approach looks at the integration and application of knowledge across these areas that can be characteristics and key features of CSET.

***Interdisciplinary Learning****:* CSET seeks to combine STEM concepts into non-STEM disciplines, allowing students to perceive how different disciplines can interconnect through collaboration.

***Real-World Applications****:* 21st Century skillsets require that K-12 Students should become familiar with real-world problems in their learning that involve strategies drawn from multiple STEM disciplines. This enhances their problem-solving skills and makes the learning more relevant.

***Hands-On Learning**:* CSET stresses practical learning. Depending on the discipline, this can include laboratory experiments, engineering design challenges, and interdisciplinary learning opportunities.

***Critical Thinking and Problem-Solving**:* In a team setting, students become competent in thinking critically, asking questions, and solving problems. This cultivates their analytical skills and prepares them for complex challenges as they matriculate in education and, ultimately, the workplace.

***Team-Based Learning**:* Throughout their academic careers, students should engage in real-world scenarios where collaboration is essential. This helps develop communication and teamwork skills.

***Connections with the Broader Community**:* This can include industry partnerships, field trips, guest lectures, and other experiences that connect students to the broader STEM community and potential career paths.

## CSET Methodology

The CSET methodology is straightforward in nature. By finding a concept that teachers want to get across to their students, they would initially use the rudiments and constructivist ideologies inherent in most classroom environments, i.e., knowledge is constructed, learning can be an active process, social activity, and contextual, and motivational prompts are essential (Mcleod, 2023, Western Governors University, 2020). The teacher would then try to produce something hands-on that students could touch and feel. Additionally, the teacher would devise three questions for each STEM discipline to ask students or have the students develop their own questions. Finally, the teaming process for student collaboration will occur.

An example would be in social sciences. If a teacher is lecturing about Egypt and the pyramids, they could 3-D print or have students make their pyramids and other artifacts. The teacher could also briefly explain the STEM concepts that were involved at the time, historically, in the making/building of those items. In this example, all four STEM disciplines can be covered. Sample questions could be the following:

***Science:*** Natural Geology - What were the pyramids made of? How were the stones excavated? What physics were involved in the construction?

***Technology:*** What technologies were used to make the pyramids, i.e., simple machines? What tools were used, and how were they constructed? How were simple technologies used to produce such a complex project?

***Engineering:*** How was the land surveyed to accommodate this structure? How was it designed to acclimate sloped walls? How were the pyramids leveled and aligned?

***Mathematics:*** What use of angles were used to construct the pyramids? How was the quantity of materials calculated? What is the ratio of the height and base? (English, 2020; Hodges, 1989; Lehner, 1997; Lepre, 1990).

This example structure can be transposed to many projects in any subject, including physical education, music, and language arts. It must be noted that this process will not work for every project or concept any non-STEM teacher might have. However, teachers in other disciplines can use this methodology judiciously in their curricula.

*Table 1. CSET Sample Interdisciplinary Topics*

| Discipline | Topic | Descriptors | Team Activities |
|---|---|---|---|
| History | Pyramids | How STEM supported this historical cultural phenomenon | Teams create STEM subject-specific questions |
| Art and Design | Creating a Moon Base | Understanding and representing the human and engineering factors for a habitat | Teams research and design moon base components (structures, biosystems, etc.) |
| Physical Education | Astronaut Training | Psychomotor apparatus and multidisciplinary skillsets (biology, psychology, food chemistry) | Teams experience individual and team-based training tasks and simulations. |
| Language Arts | Drafting a Constitution for a Moon Base | Writing Skills in an extreme environment that involves political science, law and social skills | Teams produce different constitution components |

### *Teaming*

CSET is also supported by the teaming training process - a comprehensive platform for creating transferable team and leadership skills from teacher training environments to K-12 students. Unlike the traditional collaborative learning models (cooperative learning,) teaming is based on Total Quality Management/Lean Six Sigma/Agile team development (Patel & Patel, 2021). The teaming process enables the transformation of traditional STEM education to provide environments designed to empower students with practical abilities and skills needed for retention and success in higher education and employment in STEM fields.

## Getting On Track - The Foundation Five

The “Foundation Five” rules form the basis for a supportive environment for using any interpersonal skill. These rules must be “adopted” and practiced in the classroom and, if possible, throughout the school. Ideally, anyone should be able to point out a violation of any of these rules, and the individual or group that has violated them needs to correct the behavior. Obviously, this does not happen overnight. However, when students see teachers modeling these rules and mentors modeling them, they are enforced like any other school rule. The difference is that peers should be able to enforce them with each other. This can be a "culture shift" for the institution, and culture shifts take time and nurturing, but the results can be transformational.

The students will recognize some of these rules, but talking about them and what they mean is critical to implementing them successfully. The "Foundation Five" are:

1. *Treat others the way you want to be treated.* Forms of this rule can be found in major religions of the world. Basically, most people want to be treated fairly, respectfully, thoughtfully, considerately, and in a civil manner. It is easier to frame how you want to be treated than to figure out what someone else wants, but what you want may indicate what someone else wants. If you can treat people how you want to be treated, you will exemplify the qualities they can reflect in the situation.

This rule also governs how we speak to people. Your words and your body language need to look and sound like words and body language you want to hear and see. Calm, objective language makes any situation better than emotional, accusatory, or disrespectful language.

2. *Walk the talk.* It is easy to see or say what may be right, but it may be very hard actually to do what is right. Failing to live what you say reduces your credibility and tells others that you don't value what you ask others to do. While this is difficult, it is critical to build trust; It can be the basis for establishing a positive relationship in any situation.

3. *Value another's views and worth.* Almost everyone believes that what they think is important and that they have some intrinsic worth. Making an effort to value the views of another by listening patiently and by acknowledging the value of a comment or action shows the other person that you value them. This makes it more likely that they will value your views and worth. This rule is critical in multi-cultural and multi-ethnic environments

4. *Be part of the solution, not part of the problem.* Negativity and criticism are a highly visible aspect of our culture. Negativity feeds on itself but never contributes to solutions. Working for positive or constructive solutions is a sign of a healthy institution. If the conversations in the hall, the teacher's lounge, or on the playground are positive or problem-solving in nature, that organization will succeed.

5. *Hang together, not separately.* Schools have long catered to the individual but are organized around large group management. This fosters isolation and reduces trust between teachers and students, as well as among the students themselves. The more people are committed to supporting one another, the higher the trust level and the more productive and harmonious the learning environment. Schools and classrooms that "hang together" are characterized by learning and supporting behaviors instead of restrictive and punishing behaviors. This is especially crucial in team-based learning.

### *Forming Teams*

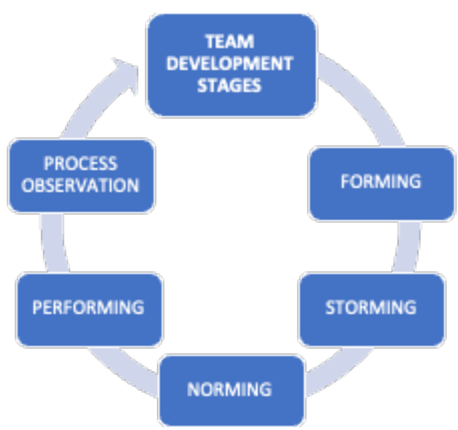
The successful use of team-based learning requires careful design of team structure. Heterogeneous teams allow members to share skills, strengthening the team as a learning unit. It enables creative thought perspectives and inclusion. The simplest schema for forming teams with different skills and abilities is to randomize selection. Have the class line up across the room. They can be organized by alphabetical order of last name and birth date or by selecting a random number from a jar. Depending on class size, have them count off, 5 or 6 being the optimal team size. Then, all the 1s, 2s, 3s, etc. become teams. The critical element of effective teaming is the ability to work with different people. This requires learning and practicing proficiency in common skill sets.

### *Team Development Stages*

All teams go through a series of developmental stages (Tuckman, 1965). They FORM – figure out who they are, what they bring to the team, what the team's purpose is (long-term and short term, and what immediate tasks need to be addressed. They STORM – naturally staking out their position as team members. This phase can be relatively quick, or it can devolve into arguments that, without facilitative intervention, can literally destroy the team at the outset. They NORM – agreeing on roles and responsibilities. They PERFORM – carry out the assigned work (Figure 1).

Teaming has three skillset components – Team Operational Skills, Interpersonal Skills, and Leadership Skills. Team formation, maintenance, and successful operation require this rigorous understanding of the competencies that underlie these three skill sets.

*Figure 1*




## Team Operational Skills

Teams operate and do work differently than individuals or dyads. Basic operations include decision-making, planning, and problem-solving. These skills underlie engineering approaches and organizational skills to succeed in complex work. These three basic activities all rely on simple process skills and ground rules that are used successfully in school and the workplace. Teaming simplifies and systematizes these operations to give any team, from 9-year-olds to adults, a powerful set of behaviors for team success. Four sub-skills are used in all three processes: brainstorming, data reduction, analysis, and decision-making techniques. Introducing decision-making using these skills is an ideal way to introduce all the operational processes.

### *Interpersonal Skills*

Many teams fail because of interpersonal dynamics – the inability of individuals and groups to understand, interact, ameliorate, and support the team members. Teaming provides a metamodel to simplify mastery of basic tools like giving and receiving feedback, coaching, and recognizing success. Interestingly, these skills are highly valued in the adult workplace and are often lacking and a source of dysfunction. Yet elementary and secondary students can master them and carry them forward. These skills promote positive relationships and create a safe space for team interaction.

### *Leadership Skills*

Even adult workers bemoan poor leadership. Teaming begins with simple facilitative techniques developed for the most advanced industries and is as effective in classroom teams as in the most advanced adult STEM work environments. Taken as a whole, Teaming is a transformative environment that supports equity and inclusion in a practical and efficacious way. It can be transformative for the school environment and is essential for the STEM work environment. Paired with comprehensive STEM education, teachers and students holistically experience content with a supporting learning dynamic.

### *Process Observation*

It is vital to monitor the health of the team. How is it functioning? Are members supportive? Is there any conflict? Is the team accomplishing its tasks? A powerful teaming tool to do this is Process Observation. This involves a member acting as an "observer" during a team session while still participating in the team's activities. The observer uses a form to lead a post-session discussion that highlights what the team is doing well and areas where they might want to do things differently.

## Starting the Teaming Journey

A simple way to begin, after the teams are organized, is to have the team make a decision, such as picking a team name, deciding on pizza toppings for the class, or picking a theme for a school event. Using the sub-skills of Brainstorming, Data Organization, Analysis, and the team's choice of decision techniques (multi-voting, weighted voting, or consensus), a decision is reached that is supported by all or at least agreeable to go forward with no "losers" to a majority.

The decision-making process is also used as a component of the team planning process, problem-solving process, and process observation at critical stages. The teachers need to identify the decision statement (or problem statement). For example: Select a name for your team. Select the type of food for a picnic. Select a color to paint the classroom.

### *Generating and Organizing Data*

Brainstorming allows every member to put forward one or more ideas. Once sufficient data is gathered, it must be organized for commonality with no judgment. Using the pyramid example, the teacher must prepare students through research-based activities that allow the teams to engage in discovery learning. The teacher could have websites or other material ready so that when the Teams are formed, they are ready to work. One team should be dedicated to science, one to technology, one to engineering, and one to mathematics.

### *Analyzing and Actual Decision*

The final two steps of the team decision-making process are to analyze candidates' ideas, questions, or solutions and discuss their strengths and weaknesses. Finally, an appropriate polling or voting strategy will give the team its final solution or conclusion. Consensus decision-making, where each member can vote yes, no, or "I can live with it," takes more time but gives each team member some interest in making the final decision work, as opposed to yes/no votes, which leaves some members out. In consensus, the team must find an alternative with all the yes or "live with it" agreements. This four-step process may seem somewhat elaborate, but based on the decision's complexity and importance, experienced teams move through it very quickly. It builds trust and participation. A team with trust and interpersonal skills values feedback, coaching, and team recognition in which the whole team is rewarded individually and as a group, which is an example of genuine equity.

Lastly, facilitative leadership skills include process observation, keeping the team on track, checking readiness to participate, checking for learning, organizing team activities, and helping teams move through the team formation stages if they get stuck.

## Teaming - A Game-Changer

Students with actual robust team skills are better equipped and better supported to handle STEM topics, which can be novel and challenging. Building trust for teams, classrooms, and schools using teaming has had positive effects, mitigating destructive behaviors like bullying, disruption, vandalism, and contentious tribalism. "Leave them alone. They are on my algebra team!"

## Conclusion

STEM should be taught as it is practiced in the real world, as interdisciplinary team-based activities. CSET embodies this pedagogical approach. This article defines, explains, and exemplifies this strategy through a taxonomy of skill sets, best practices, and how to transfer these concepts into classroom activities. This new way of thinking about STEM education allows all teachers to become STEM practitioners who can manage the inquiry and collaborative processes of the STEM workplace, which will ultimately provide real-world insights for students who will be involved in the STEM workforce.

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