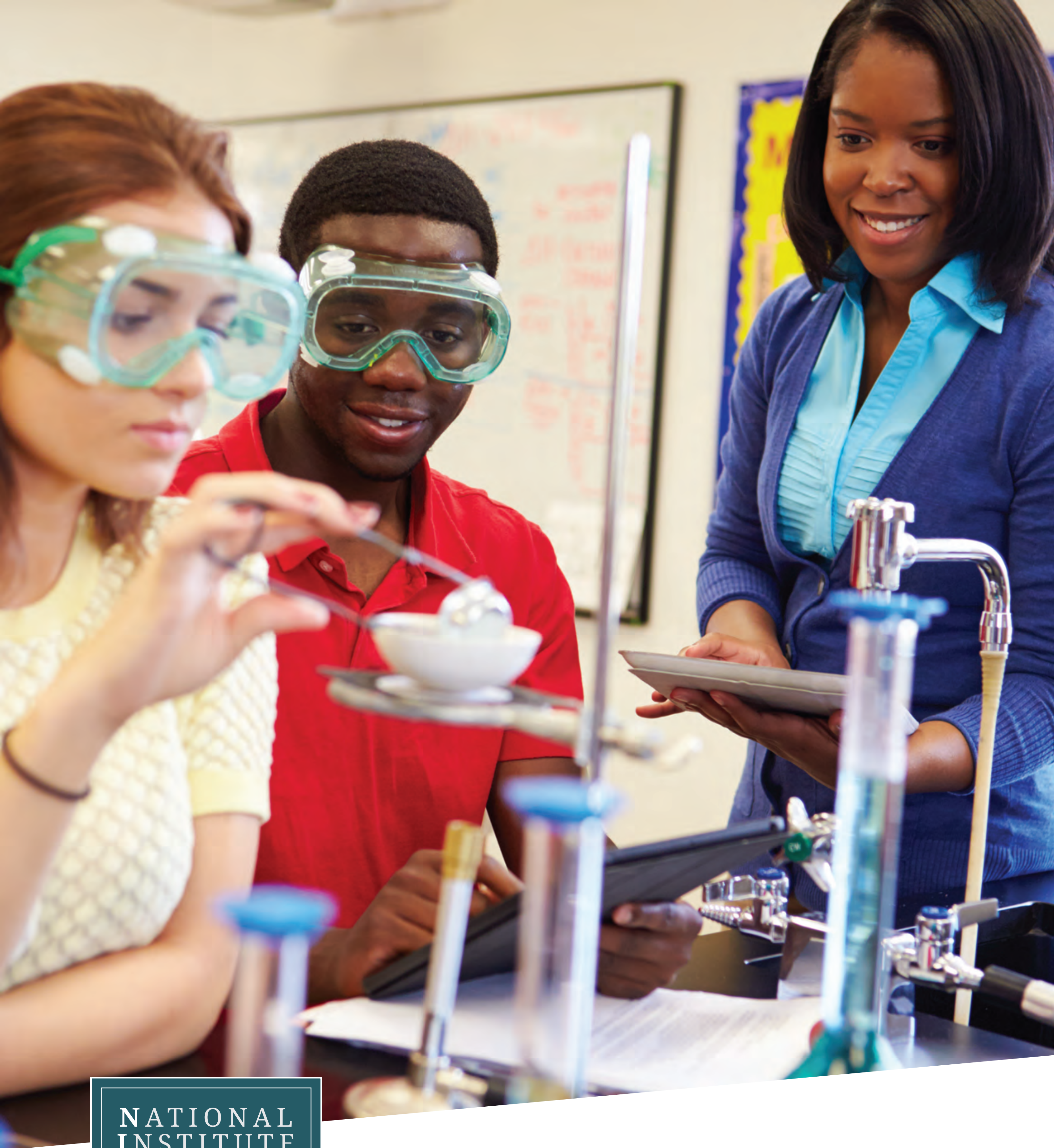

NATIONAL INSTITUTE *for* STEM EDUCATION

THE STEM OBSERVATION PROTOCOL

Teacher Actions that Matter in a STEM-centered Classroom

DR. TERRY TALLEY

Terry Talley, Ed.D.

Teacher Actions that Matter – Research Base

"A classroom with an effective teacher is associated with growth in student learning at a rate that is three times greater than that in a classroom with a low-performing teacher," according to authors Tony Frontier and James Rickabaugh (2014). How is an effective teacher identified and what are the varying degrees of effectiveness? In the STEM classroom an effective teacher selects actions that have an impact on student achievement.

Education researcher John Hattie, in his study called *Visible Learning: A Synthesis of Over 800 Meta-analyses Relating to Achievement* (2009), stated that contrary to conventional wisdom, "influences associated with the home and the school have less significant effect on student learning than the characteristics of the teacher, the quality of the curricula, and the quality of teaching."

Frontier and Rickabaugh (2014) go on to state, "Each teacher's ability to use the right strategy, in the right way, at the right time holds the greatest potential to improve student learning." Their book *Five Levers to Improve Learning: How to Prioritize for Powerful Results in Your School* is based on Hattie's research. Using the lever as a metaphor, the authors compare the funding and time spent improving student achievement to levers used to move large objects. For each of five different levers that districts and schools use to influence student learning—Structure, Sample, Standards, Strategy, and Self—the two most powerful, in spite of the smallest lever, are the last two. "At the core of effective teaching is a reflective teacher who can use instructional strategies that are responsive to student learning needs… and the self-efficacy of the learner and the teacher to believe the student is capable of learning and will be supported by a caring teacher."

The National Research Council (NRC) study *How People Learn: Brain, Mind, Experience, and School* (1999) specifically indicates three key findings for student learning that target specific teacher actions. These findings address the misconceptions students bring into the classroom that, unless addressed through instruction, students will reject new learning. They also address the need for a deep foundation in useable knowledge and the ability to organize them in a way that makes them retrievable. Finally, they found that students can be in control of their own learning by defining their goals and monitoring their own progress towards achievement. The findings and related teacher actions are:

1. Recognize preconceptions and adjust instruction
   Teacher Actions: Include structured strategies to elicit and challenge student preconceptions and incorporate background for the teacher about common preconceptions.

2. Understand the content and conceptual framework for a discipline and provide examples for context.
   Teacher Actions: Organize content around a conceptual framework, connect factual information to the framework, and provide relevant examples to illustrate key ideas.

3. Provide class time for goal setting and analysis, and teach metacognitive skills.
   Teacher Actions: Make learning goals explicit and integrate metacognitive skill development into content.

The NRC study (2009) goes on to state that the learning environment of the classroom must be learner-centered. The learning centered classroom pays attention to what is taught, why it is taught, and what mastery of the information looks like. Formative assessments are intended to help students and teachers monitor progress in mastery. Learning is influenced in positive ways when it is in a context that is community-based and requires connections to the outside world.

Many reports attempt to identify instructional strategies that work. One such report, prepared by William Bennett in 1986, is called *What Works: Research about Teaching and Learning.* He stated, “Teaching is not as mysterious as some might think and that research can and should provide some clear guidance on the specifics of effective teaching.” His list of strategies included use of experiments, teacher estimation strategies, teacher expectations, effort reinforcement, direct instruction, memorization, questioning, homework, and classroom assessment.

The research reported by Robert J. Marzano in *What Works in Schools: Translating Research into Action* (2003), was the basis for the challenge to reform public schools using research-based findings rather than lofty rhetoric from a centralized school system. He concluded that changes in actions at the teacher level, including instructional strategies, classroom management, and classroom curriculum design, need to take place at the campus level to become highly effective in enhancing student achievement.

Hattie (2009), Marzano (2003), Frontier and Rickabaugh (2014), and the National Research Council (1999) use the statistical measure of *effect size* to determine the levels of effectiveness for each instructional practice or strategy in affecting student learning and increasing achievement. Hattie specifically addresses an effect size of 0.40 or greater as the *hinge point*. It is at this point that the actions of the teacher have a positive effect on student learning. He also asserts that some teacher actions can have a negative impact on student learning. Those are the ones that fall between 0 and -0.2 in effect size. Those between 1 and 0.4 are positive impacts but not more that a year’s growth, which can be expected with maturation of the student or what happens in good classrooms.

Robert Marzano (2003) measured the effect size for the actions that his research found had a strong impact on student learning include:

Identifying Similarities and Differences	Effect Size:	1.61
Summarizing and Notetaking	Effect Size:	1.0
Reinforcing Effort and Providing Recognition	Effect Size:	0.80
Homework and Practice	Effect Size:	0.77
Non-linguistic Representations	Effect Size:	0.75
Cooperative Learning	Effect Size:	0.73
Setting Objectives and Providing Feedback	Effect Size:	0.61
Generating and Testing Hypotheses	Effect Size:	0.61
Questions, Cues, and Advance Organizers	Effect Size:	0.59

Within the research findings of the National Research Council for the development of *A K-12 Framework for Science Education*, (*Framework*, 2012), Roger Bybee concluded that "There is no doubt that science – and therefore science education – is central to the lives of all Americans. Never before has our world been so complex and science knowledge so critical to making sense of it all." It was his charge that science and STEM education needs to be more than a list of facts or an accumulation of knowledge: it is in the practices of scientists and engineers that students are able to use their accumulated knowledge to explain the phenomenon of the natural world. That is the true definition of science. The practices of scientists and engineers included in the *Framework* include:

- Asking questions and defining problems
- Developing and using models
- Planning and Carrying out Investigations
- Analyzing and interpreting data
- Using mathematics, information, and computer technology and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

The Observation Protocol

Based on the research findings and recommendations of the three meta-analyses and the National Research Council, the authors of the Observation Protocol selected 16 teacher actions to consider when conducting observations. The Observation Protocol is divided into three domains with between four and six teacher actions each. The strategies and practices identified as teacher actions were found to be highly effective in education research for STEM instruction. The protocol is divided into domains that center around clusters of teacher actions. The three observable domains with the actions are listed below:

Domain 1: Creating an Environment for Learning (E)

Action 1: Creating a Positive Classroom Culture (E-1)
The classroom environment must be a safe place for students so that they feel comfortable taking risks and engaging in the learning experience. This teacher action includes all practices that encourage a positive relationship between the teacher and the student and among students, and extends to the wider community.

Action 2: Establishing Cooperative Learning (E-2)
Cooperative learning is an essential component of a classroom that seeks to develop social and interpersonal skills in students. This teacher action includes the practices that infuse collaboration into the learning environment.

Action 3: Integrating Technology (E-3)
Technology is an unavoidable part of modern society. The ubiquity of technology requires a citizenry familiar with various forms of technology and how to select, evaluate, and effectively apply them. This teacher action includes those practices in which the teacher does not replace instruction with technology, but rather leverages technology to enhance effective instruction.

Action 4: Connecting Learning Outside the Classroom (E-4)
One of the essential goals of education is to prepare students for the world outside the classroom. In addition to preparing students, making connections to the real world provides students with a framework for demonstrating the relevance of their learning. This teacher action includes those practices that encourage students to see the connection between the content of the classroom and the world outside of school.

Domain 2: Building Scientific Understanding (U)

Action 1: Implementing Inquiry (U-1)
A lifelong learner is one who is able to generate and answer his or her own questions. Creating this kind of learner requires experience with all aspects of inquiry. This teacher action includes those practices that de-emphasize the role of the teacher as a central repository of information and increase the role of the student as a participant in and architect of his or her own learning.

Action 2: Addressing Student Misconceptions (U-2)

It is impossible for students to integrate a new concept if it conflicts with an established mental construct. An important first step to learning is breaking down misconceptions. This teacher action includes those practices that assist students in identifying their misconceptions so that they can begin to construct a more accurate understanding.

Action 3: Facilitating Questioning and Discourse (U-3)
An essential aspect of facilitating student understanding is insight into student thinking. Observing how students are able to communicate their understanding best provides this insight. This teacher action includes those practices related to effective questioning and meaningful communication that establishes what students know and are able to do.

Action 4: Utilizing Assessment (U-4)
Assessment that informs instruction is essential if teachers are to select and implement learning experiences that lead to student understanding. This teacher action includes those practices that implement authentic assessment strategies, which allow teachers to use data to improve learning opportunities.

Action 5: Building Scientific Literacy (U-5)
The field of science has its own set of skills and knowledge. As science continues to play a greater role in society, the need to be scientifically literate is increasingly important. This teacher action includes those practices that promote in students the skills of practicing scientists and scientifically literate citizens in students.

Domain 3: Engaging Students in Scientific and Engineering Practices (P)

Action 1: Cultivating Scientific Investigations (P-1)
The skills inherent in designing and implementing a scientific investigation are applicable to many situations outside of the science classroom. Skills such as observing, asking questions, collecting and analyzing data, and drawing and communicating reasonable conclusions are important to all individuals. This teacher action includes those practices that help students develop the skills associated with scientific investigation.

Action 2: Developing Engineering Solutions (P-2)
The skills used by engineers to identify and solve problems are useful well beyond the science classroom and are an important part of being able to function in and contribute meaningfully to society. This teacher action includes those practices that immerse students in the iterative engineering design process.

Action 3: Fostering Data Utilization (P-3)

Within the science classroom and in the real world the ability to analyze and communicate the conclusions drawn from data is essential. This teacher action includes those practices that develop the mathematical and communication skills students need in order to qualitatively and quantitatively analyze data and explain its meaning.

Action 4: Implementing Project-based Learning (P-4)
Project-Based Learning (PBL) not only more accurately reflects the nature of how skills are applied in the real world, but it also creates a learning environment more likely to engage students. This teacher action includes those practices related to the implementation of PBLs. A necessary characteristic of PBL is that it promotes mastery of the content and process standards using an integrated and holistic approach.

Action 5: Facilitating Claim-Evidence-Reasoning (P-5)
A fully literate person needs to be able to effectively state a claim, cite appropriate evidence, and connect the evidence to the claim using reason (Claim-Evidence-Reasoning, or CER). In addition to representing an important group of skills, CER is a valuable form of authentic assessment in the science classroom. This teacher action includes those practices that will develop in students, ability to use the CER method.

Action 6: Promoting Scientific Argumentation (P-6)
Scientists must be able to use evidence to explain their understanding of a phenomenon. Once evidence has been analyzed into a claim, backed by scientific reasoning, there is the possibility that another explanation can be drawn from the same evidence based on different expertise and background knowledge. Argumentation is the scientific way to present and analyze evidence that can generate more than one claim statement.

Indicators further break down the actions. For each action there are between one and six indicators that more clearly specify qualities of a learning-centered classroom. The Protocol is based on the stages of growth in a teacher's career, and feedback is given based on the developmental level of his or her teaching practice.

Below is an example of the further qualities the indicators highlight and the qualifiers for the indicator.

Domain 1: Creating an Environment for Learning (E)

Action E-1: Creating a Positive Classroom Culture

Indicator 1: Student- Teacher Interaction
The degree to which verbal and nonverbal interactions between teacher and student establish a learning-centered culture

Indicator 2: Classroom Procedures
The degree to which the set of established routines and procedures manage and organize student behavior

Indicator 3: The Physical Space: Safe and Accessible
The degree to which aspects of the physical environment relate to safety and student interaction with materials

Indicator 4: The Physical Space: Student Interactions
The degree to which aspects of the physical environment relate to student interactions

Indicator 5: Teacher and Classroom Focus
The degree to which the teacher's predominant focus falls the continuum between managing non-academic student behaviors and facilitating those behaviors that encourage student inquiry and content mastery

Indicator 6: Response to Failure
The degree to which the attitude in the classroom relates failure and growth

Indicator 7: Respecting Individuality
The degree to which teacher attitude towards those aspects of individual students contribute to their uniqueness

The premise of Carol Dweck in her book *Mindset, The New Psychology of Success: How We Can Learn to Fulfill Our Potential,* (2014), depending on where a person is in their growth as a professional, some “may not be there yet.” Her premise is that all people with a growth mindset will eventually reach their full potential, but depending on their level of practice, they might not be there *yet*. Dweck suggests providing feedback on their current level of practice so that they can honestly evaluate where they are. Teachers can then seek ways to change their own practices to have a greater impact on student achievement.

The stages in teacher growth are novice, gaining skills, proficient, and role model. A teacher with numerous years of experience can range from novice to proficient based on the actions and successful implementation observed. When comparing a role model teacher to a proficient teacher, disregarding the number of years teaching experience, it is the role model teacher who has utilized research-based practices and the impact on student learning is evident and observable.

In order to offer feedback that is actionable, each indicator specifies a level of proficiency based on the teacher's developmental level and its impact on student achievement.

An example of the qualifiers for each of the indicators in Action 1 in Domain 1 is shown below:

Domain 1: Creating an Environment for Learning (E)

Action E-1: Creating a Positive Classroom Culture

Indicator 1: Student- Teacher Interaction
The degree to which verbal and nonverbal interactions between teacher and student establish a learning-centered culture

Novice: The majority of the teacher's interactions with students are consistently negative, impatient, and harsh—irrespective of proximity.

Gaining Skill: The teacher's interactions with students are predominantly positive, patient, and inviting. Some interactions are negative, impatient, and harsh—irrespective of proximity.

Proficient: The majority of the teacher's interactions with students are consistently positive, patient, and inviting. The teacher maintains proximity to the students and moves among the students.

Role Model: The teacher is consistently positive, patient, and inviting when interacting with all students. The teacher's positive demeanor is reflected in the interactions among students. The teacher maintains proximity to the students and moves among the students.

Administering the Observation Protocol

An observation of a STEM teacher takes one class period. It should last from the start of the day's STEM lesson to the end. It needs to be at least 30 minutes and is best when it is between 45 and 60 minutes. Notifying the teacher of a scheduled observation allows the teacher to prepare sufficiently and prepare documentation. Prior to the observation we recommend that teachers complete a pre-observation survey that assesses the value they place on each of the actions in rank order. The observer then provides a window for the observation that is not on a testing day, test-review day, or the day before or after a student holiday.

Providing the teacher an opportunity to pre-assess their own perception of the impact their actions have on student learning is enlightening when they calibrate the results of their self-assessment to that of the observer's assessment. Based on the study by the

TNTP called the *Mirage: Confronting the Hard Truth About our Question for Teacher Development (Mirage, 2015),* 83 percent of teachers rank themselves as being proficient or a role model compared to an observer's assessment rating them at being novice or gaining skills. It also found that teachers who have been in teaching for more than five years no longer continued to improve their practice.

The developmental levels of each of the indicators are quantified with Novice as 1, Gaining Skills 2, Proficient 3, and Role Model as 4. These are totaled per action and averaged at the action level. It has been found that combining the averages for domains ends up providing a skewed picture of the teacher's skills. It is best to keep averages to the action level to most appropriately make choices for professional growth.

The Protocol can be used to show the best indications of a need for professional growth towards the impact of instruction and student achievement. We recommend conducting three observations per year: one at the beginning of the year, one at the middle of the year, and one at the end of the year. By graphing observation data by action, the teacher can determine their growth towards more effective instructional actions.

The instructional leader who is responsible for STEM instruction and practices on the campus is the best person to administer the Protocol. When pressed for time or when doing multiple short walk-through observations, the observer can use a checklist to note and comment on observed teacher actions. Scoring for quality is not the intention; instead it is feedback to the teacher about what was seen. Including comments about the quality of a selected action that can be judged by student engagement and responses is also appropriate.

Professional Development

When considering the amount of funding provided to support teacher growth and development for the academic achievement of the students, it is important to take into consideration the quality of the outcomes for that level of spending. According to a study by the TNTP called the *Mirage (2015)*, the national average amount of funds in all budget items that are spent to improve teacher quality totaled over $18,000 per teacher. That takes into consideration things such as: principal and administrator time spent on teacher evaluations and walk through observations, in-service days and district PD days, the additional district staff that is hired to provide instructional support, substitute days so teachers can attend PD, staff salaries for the PD department at the district office, teacher and administrator conference registrations and travel, consultant fees, stipends paid to teacher to attend trainings, as well as the many other items that are intended to change teachers' instructional practice so that student achievement is improved.

When professional development is aligned to the teacher actions that are observed and evaluated, decisions about how to support teachers who desire to gain role model quality is based on empirical data from the Observation Protocol. The qualifiers for each action are quantified and the average score is the basis for recommending specific professional development. Teachers should be provided choices in the way they become more highly qualified in their selection of the appropriate actions based on their developmental level and the mode of learning they prefer.

The TNTP's report, *Mirage* (2015), suggests a broad range of activities, such as: "traditional one-time professional development, extended development programs, independent teacher efforts, formal and informal peer collaboration, receiving direct coaching, completing university coursework, time with a formal evaluator, peer observations, administrator observations, feedback, technique practice, follow-up support, and new teacher preparation and mentoring."

In Conclusion

Accelerate Learning, in conjunction with the National Institute for STEM Education, developed the STEM Observation Protocol as a tool to make decisions about how best to support teachers as they endeavor to influence student achievement. More information can found on the NISE website.

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