



PUBLIC WORKS

STEM Reform

POLICY BRIEF

Instructional Practices
at the Core of an
Integrative STEM
Approach to Learning

21st Century Learning Standards, Pedagogy & Professional Learning

This policy brief was developed by Public Works to support the California Mathematics & Science Partnership (CaMSP) program of the California Department of Education's Professional Learning Support Division's Science, Technology, Engineering and Mathematics (STEM) Office.

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SCIENCE, TECHNOLOGY, ENGINEERING & MATHEMATICS (STEM) LEARNING

Renewed attention to improving mathematics and science education has reinvigorated the ideas of integrated and applied STEM (Science, Technology, Engineering and Mathematics) learning as both a promising approach to reforming public education and to better match the needs of the US economy to have a globally competitive workforce. From training STEM teachers through the 100kin10 initiative, which aims to recruit 100,000 STEM teachers over the next decade to Educate to Innovate designed to inspire boys and girls to pursue STEM careers, STEM preparation is a frequent topic of educational reformers, the business community and policymakers at all levels of government.¹

A HISTORICAL PERSPECTIVE ON PEDAGOGICAL REFORMS IN K-12 EDUCATION

When most people picture a classroom, the image is usually of a teacher standing in front of a large classroom of students lecturing them on a given (usually very specific) topic or set of problems to complete, while students listen, take notes and search for the correct answer when prompted. This traditional mode of teaching reflects the roots of education as preparation for a classical university education among the elites but even more firmly took hold as an efficient way to educate large numbers of students as the availability of public education began to expand with the industrial revolution.

While the traditional approach to education solidified as the population grew, at the same time, education in the early 20th Century was also influenced by progressive ideas of learning rooted in personal experience and emphasizing learning by doing introduced through the fields of psychology, learning theory and other university disciplines. The post-World War II period in America was characterized by the growth of the middle class and a greatly expanded, yet increasingly centralized, public education system. We began to envision college for more than just the few and put in place a more robust public postsecondary system. This system helped to meet the new demands of our economy, our new role in the world as a global superpower, and global political and national defense threats – such as the launch of Sputnik in 1957, which resulted in greater support for mathematics and science education, NASA, and the space race of the 1960's.

Under the reforms of President Johnson's Great Society and influenced by demands for civil rights and social justice, the initial Elementary and Secondary Education Act (ESEA) of 1965 was the first significant infusion of federal funding in public education, which provided extended funding for special education, and additional funding to schools with high concentrations of poverty. ESEA established Head Start, strengthened the federal role in educational research, and supported new roles for state departments of education. This entry of the federal government in public education evolved over the next several decades to support the development of national priorities related to educational reforms, curricular standards (first at the state level and now across the nation), stronger test-based accountability systems, and other centralized functions for a more consistent administration of public education at the federal, state, and local levels. The tension

Beyond the quiet classroom and think-pair-share, encouraging discourse and active learning in an inquiry-based environment...

Throughout the curriculum, new standards are relying on teachers to move away from direct instruction and a reliance on textbooks toward using instructional strategies that evoke more elaborate responses or explanations from students.

A point of agreement among mathematics and science educators is that all inquiry involves asking questions and framing explanations.

Effective teaching also builds upon children's questions and natural curiosity, and seizes upon teachable moments and opportunities for independent learning.

Thinking like a scientist or a mathematician is one way to introduce these ideas and build off what we know about how children learn.

¹ Reported by Liana Heitin on November 25, 2014, *Education Week, Curriculum Matters*.

between traditional and progressive approaches is a thread in education reform that continues to this day as solutions to national problems are sought, policies and approaches are debated and education initiatives are introduced.

21ST CENTURY STANDARDS

In 2009, through the US Department of Education (USDE) and the Race to the Top Fund, states were encouraged to pass legislation to adopt common standards to prepare students to succeed in college and the workplace. The Common Core State Standards Initiative (CCSSI) was a state-led effort coordinated by the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO). The mathematics (CCSSM-M) and English language arts (CCSS-ELA) standards developed under this initiative were adopted in California in 2010 and are also being implemented in many states across the nation. In adopting these standards, California joined the Smarter Balanced Assessment Consortium (SBAC), one of two consortia funded by the USDE to develop assessment systems aligned to the new standards. In addition to the CCSSI taking hold across the nation, a parallel effort by the National Research Council resulted in a new framework for K-12 science education and the Next Generation Science Standards (NGSS), which were adopted in California in 2013.

The CCSS-M emphasizes focus and coherence by laying out a logical sequence of student learning from grade to grade designed to lead to college and career readiness by the end of high school. CCSS-M includes traditional mathematical topics and mathematical practices that focus learning on the important processes and proficiencies that have long been important in mathematics education.² NGSS is focused on developing a deeper understanding of science, in part, by asking students to use the same kinds of practices that scientists use and introduce the concepts of engineering design to science education.³

As we enter the second decade of a new century, the school reforms envisioned by proponents of integrated STEM, CCSS-M, and NGSS will need to bring several strands of education reform to the forefront including: (1) embedding research about how students learn into the classroom, (2) understanding how student motivation and self-direction in students improves outcomes for all and (3) the role of the teacher as a facilitator who can access structured professional collaboration and a more comprehensive approach to continuous professional learning.

Key Components of Encouraging Self-Efficacy in Learning

- *Mastery orientation vs. absolute performance*
- *Supporting adaptive patterns characterized by challenge-seeking and persistence in the face of obstacles*
- *Explicitly teaching students cognitive and self-regulatory strategies*
- *Using experience and reflection*
- *Metacognitive strategies*

LEARNING THEORIES AS THE FOUNDATION FOR EDUCATION REFORM

Seeking middle ground between traditional, didactic forms of education with the freedom of progressive education, John Dewey advocated in the 1930's for a middle ground approach to learning. Dewey described an approach to learning that blended experiences and the freedom of students to think for themselves with the need for grounding those thoughts in the basic components of the principles or subject matter of the lesson being taught. The educator's role was to guide and reorganize students toward a productive learning experience, much like the idea of the "facilitator" of learning advocated today in strategies such as problem based or project based learning where the teacher is not necessarily the expert on all

subject areas but possesses instructional expertise, which is used to guide students and help solve problems.⁴

Teachers Need Structured Support to Build Pedagogical Skills

- *Support structures must be established in schools to facilitate teachers' pedagogical growth throughout their careers.*
- *School support structures that are effective at facilitating teachers' pedagogical growth include coaching and mentoring, lesson study, and professional learning communities.*



2 Rothman, R. (2011). *Something in Common: The Common Core Standards and the Next Chapter in American Education*. Cambridge, MA: Harvard Education Press.

3 Maxwell, L. A. (2013, July 10). *New Science Standards Designed for Wide Range of Learners*. *Education Week*. Retrieved from edweek.org.

4 Dewey, J. (1938). *Experience and education*. New York, New York: Macmillian Publishing Company.

Lev Vygotsky introduced the concept of the zone of proximal development in the early 1930s, which grew in prominence and was embodied in the reforms of the 1960s and 1970s, where it was used as a way to support equal opportunities to learn when children of all backgrounds entered public school.⁵ The zone of proximal development focuses on how individuals interact in the learning process considering actual development level and potential development under adult guidance or in collaboration with more capable peers.

More recent iterations of these ideas can be found in the experiential learning movement of the 1980s. In experiential learning, ideas are not fixed. Rather, elements of thought can be formed and reformed through experience. Building off these ideas, research provided evidence of effectiveness in raising student motivation and higher order thinking skills when students and teachers collaborated and when learning was active and applied.

Student motivation and self-efficacy research supports the idea of classroom settings promoting “mastery” versus absolute standards of achievement as encouraging students’ desire to learn and improve even after controlling for prior achievement. Students’ perceptions of tasks and activities not only influence how they approach learning, but also have important consequences for how they use available information to make judgments, their willingness to apply effort to strategies they initiated and feelings of satisfaction related to being competent at a given subject or task. Allowing students to have a say in establishing priorities for task completion, method of learning or pace of learning is also a way of giving responsibility to students.

California Superintendent for Public Instruction Quality Professional Learning Standards

- *Data*—quality professional learning uses varied sources and kinds of information to guide priorities, design and assessments.
- *Content and pedagogy*—quality professional learning enhances educators’ expertise to increase students’ capacity to learn and thrive.
- *Equity*—quality professional learning focuses on equitable access, opportunities, and outcomes for all students, with an emphasis on addressing achievement and opportunity disparities between student groups.
- *Design and structure*—quality professional learning enables educators to acquire, implement, and assess improved practices.
- *Collaboration and shared accountability*—quality professional learning facilitates the development of a shared purpose for student learning and collective responsibility for achieving it.
- *Resources*—quality professional learning requires dedicated resources that are adequate, accessible, and allocated appropriately toward established priorities and outcomes.
- *Alignment and Coherence*—quality professional learning contributes to a coherent system of educator learning and support that connect district, school, and individual priorities and needs with state and federal requirements and resources.

MOVING TO A PROFESSIONAL LEARNING MINDSET

Across the United States, educational reform efforts are dramatically raising expectations for students and teachers. To meet these new expectations, teachers will need to deepen their content knowledge, and learn new methods of teaching. As a result, teachers also require more time to work with colleagues, to critically examine the new standards being proposed, and to revise their curricula. Teachers will also need opportunities to develop, master, and reflect on new approaches to working with children. These activities typically fall under the umbrella of professional development.

In past reform efforts, professional development has been characterized almost exclusively in terms of formal education activities, such as courses or workshops several times a year. During these formal education activities, most school administrators released their students for a half or full day to hold an in-service program that may or may not be relevant to individual teacher professional needs. In contrast, high quality professional development is a central component in nearly every modern proposal for improving education. Policymakers increasingly recognize that schools cannot be better than the teachers and administrators who work within them.

California’s Superintendent’s Quality Professional Learning Standards (QPLS) focused on developing standards that can become the cornerstone of the new mindset of quality professional learning over the course of a teaching career or implementation

⁵ Vygotsky, L.S. (1978). *Mind in Society. The Development of Higher Psychological Resources*. Cambridge, MA: Harvard University Press



of new initiatives. The OPLS identify elements of quality professional learning that cut across specific content knowledge, pedagogical skills and dispositions.

Teachers who aim to be school leaders on their campuses share the visions of their schools, align their professional goals with those of their schools and districts, and assume responsibility for the success of their schools as a whole. Teacher leaders can lead conversations to engage their peers and strengthen instruction. Including such opportunities for teachers who aim to be leaders on their campuses during professional learning programs is especially important for educators today, as the support of school teacher leaders will become essential during our state and nation's imminent implementation of CCSS-M and NGSS.

About the California Mathematics and Science Partnership

The California Mathematics and Science Partnership (CaMSP) program began in 2004. CaMSP is funded by a statewide competitive grant program administered by the Professional Learning Support Division's Science, Technology, Engineering and Mathematics (STEM) Office of the California Department of Education (CDE) under the Improving Teacher Quality (ITQ) component of the No Child Left Behind Act of 2001. Since that time, over 100 partnerships of local school districts and universities have been authorized by CDE involving hundreds of schools and many thousands of teachers. More information can be found at: www.cde.ca.gov/pd/ca/ma/camspintrod.asp

About Public Works

Public Works is a non-profit corporation founded in 1998 dedicated to working with schools, government agencies and the non-profit sector by providing services and resources to organizations that educate and inform children, youth and families. Our mission is to put data into action, transforming statistics into information that informs decisions, improves accountability and communicates the impact of public policy. Public Works serves as the statewide and local evaluator of the CaMSP program. More information can be found at www.publicworksinc.org.



**90 N. Daisy Ave.
Pasadena, CA 91107
626.564.9890**