Specialty High Schools to Support STEM Teaching and Learning

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Abstract

In the report, Rising Above the Gathering Storm, a number of policy recommendations were outlined to increase U.S. competitiveness in the 21st century economy. One of the most interesting recommendations was the call to states to develop statewide specialty STEM high schools (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007, p. 6). Specialty high schools as described in the report would focus on preparing students in STEM disciplines, including the sciences. In addition to focusing on science for students, these schools could support the next generation of science teachers by providing a training venue for inquiry-based pedagogies needed to support more effective STEM teaching and learning. Project-/Problem-Based Learning (PBL) are pedagogies that provide effective teaching strategies to support science education reform initiatives when implemented with fidelity. In 2010, the state of Texas in the United States authorized the creation of STEM Academies. STEM Academies are specialty high schools similar to those described in Rising above the Gathering Storm. In an effort to improve STEM teaching and learning, it was recommended that the primary instructional strategies of the academies would be Problem- and Project-Based Learning. In the science context, PBL is well suited as a primary pedagogy for learning. PBL aligns well with the process of scientific inquiry. This research paper examines the role of PBL in supporting students in the science classroom in the context of STEM focused academies, including the results of a 7-year longitudinal study that examined student achievement as measured by state accountability exams.

Keywords: *Problem-Based Learning, Project-Based Learning, fidelity, STEM, Evaluation.*

1. Introduction

In 2011, the University of Texas at Tyler developed the University Academy, a STEM Lab School district in response to concerns about the future competiveness of American students in the STEM disciplines. The academies would implement inquiry-based pedagogies as the primary instructional strategies to be utilized by teachers. Inquiry-based pedagogies are recommended as model pedagogical approaches for the teaching of Science, Technology, Engineering, and Mathematics (STEM). There is significant support for teaching science through inquiry in the research literature [1]. Inquiry approaches are also frequently cited in the research literature as a way to develop 21st century skills that are needed to be successful in the STEM workforce [2]. Initially, the academies experienced a number of challenges in implementing an inquiry-based school model. As a result, scores on state accountability tests were not at the desired level. As a result, the academy district implemented the Texas STEM Academy Blueprint Model funded by the Texas Education Agency to guide the school design for the future [3]. The blueprint aligns well to recommendations made in the report, Rising Above the Gathering Storm (RAGS). One of the recommendations in the report was to create "specialty" STEM focused high schools as a strategy to improve STEM teaching and learning and increase the number of high school graduates entering STEM majors in higher education and the STEM workforce [4]. The opening of the new STEM academy district provided an opportunity to conduct longitudinal research on the implementation of the T-STEM Blueprint in an authentic setting from creation to present day and examine science achievement over time in a school designed specifically to address STEM though inquiry. It should be noted that the STEM Academy district is open enrolment and free of charge. Any student may enrol. There are no admission tests or requirements other than students must live in the attendance zone.

1.2 The Texas STEM Academy Blueprint

The Texas STEM Academy Blueprint was developed to guide school district in designing and opening new schools as STEM Academies or redesign existing schools to become STEM Academies. Academies use the blueprint to create schools that address seven benchmarks. The benchmarks include:

1. Mission driven leadership;
2. School culture and design;

3. Student outreach, recruitment, and retention;
4. Teacher selection, development, and retention;
5. Curriculum, instruction, and assessment;
6. Strategic Alliances; and
7. Advancement and sustainability.

For the purposes of this study, the researchers focused their attention to Benchmark 5: Curriculum, Instruction and Assessment. Benchmark 5 guides the development of the curriculum including teaching strategies and assessment requirements. Table 1, provides an outline of Benchmark 5 requirements.

Table 1: Benchmark 5: Curriculum, Instruction and Assessment

5.1	Rigor: Aligned Curriculum & Assessment, Endorsement, 12-30 college credits.
5.2	STEM-focused Curriculum: STEM electives, PBL, STEM Extracurricular, Portfolios, Internship/Capstone
5.3	Instructional Practices: Data-driven, PBL, Student choice/voice
5.4	STEM Education Integration: Innovate, Invent, STEM literacy, Technology
5.5	Literacy: 21st Century Skills, Read, Write, Speak, Present, STEM Vocabulary
5.6	Assessment: Standards, Diagnostic, Summative, Performance-based, Tracks

To meet the requirements of each sub-benchmark, the school implemented common planning times for all core teachers. As a result, all science teachers met daily as a team as part of a Professional Learning Community and were provided time during the school day to collaborate and design a curriculum that met the benchmark [5][6]. Teacher were also trained in problem- and project-based learning to assure a common instructional approach. This is ongoing process.

2. Research Methodology

The research was conducted as part of a mixed-methods evaluation [8] that has been ongoing since the academy opened. The primary intervention that was examined was the introduction of problem- and project-based learning as the primary instructional strategy for the academy. The researchers utilized student achievement results in science as measured by the state accountability exam as the measure of impact. Accountability exams are given to all public schools in the spring of each year. In addition to examining science achievement data, the researchers also utilized the T-STEM Blueprint Rubric to examine implementation fidelity for meeting Benchmark 5. The academy is rated annually on blueprint implementation. Each benchmark is given one of the following ratings based upon evidence that the academy provides to the evaluators. Ratings include:

- Developing (D)
- Implementing (I)
- Mature (M)
- Role Model (R)

The goal is to become a Role Model academy over time.

3. Results

Table 2 shows the impact of pre- and post-intervention on science achievement and provides district and state average scores.

Table 2: State assessment scores pre-and post-intervention

Year	2013	2014	2015	2016	2017	2018	2019
Pre/Post	Pre	Pre	Post	Post	Post	Post	Post
District	54	67	78	88	85	88	93
State	79	78	78	80	79	76	81

Science scores on state accountability tests have improved annually since the implementation of the blueprint and the inquiry-based instructional strategies. Science achievement continues to be higher than the state average.

Table 3 shows fidelity to the blueprint over time as rated using the T-STEM Blueprint Rubric. This study focused on Benchmark 5: curriculum, instruction, and assessment. Prior to the intervention, ratings defaulted to “Developing”.

Table 3: Benchmark 5 Rating over Time

Indicator	2013	2014	2015	2016	2017	2018	2019
Pre/Post	Pre	Pre	Post	Post	Post	Post	Post
5.1	D	D	I	M	M	R	R
5.2	D	D	I	M	R	R	R
5.3	D	D	I	I	M	M	R
5.4	D	D	I	I	I	M	M
5.5	D	D	I	I	M	M	R
5.6	D	D	I	M	R	R	R

Note: D =Developing; I = Implementing; M = Mature; R = Role Model.

4. Conclusions

Tables 2 and 3 in the previous section show continuous improvement. These data suggest that implementing Benchmark 5 with fidelity is correlated to increased science achievement as measured by the state accountability exam in science. These data provide evidence that the implementation of problem- and project-based instruction as outlined in the Blueprint may be an effective strategy for improving science teaching and learning.

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