Partnership to Improve Student Achievement in Physical Science: Integrating STEM Approaches (PISA²)

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STUDENT SUCCESS

PISA² aims to increase the academic achievement & 21st century skills of elementary & middle school students in science & engineering by enhancing science content knowledge, pedagogical content knowledge & attitudes & beliefs of teachers about STEM subjects.

Students constructing a circuit

Teachers learning concepts of electricity

Students wiring a model house

PARTNERS, ROLES

Stevens Institute of Technology – Faculty from the Stevens Schaefer School of Engineering & Sciences working collaboratively with representatives of the Center for Innovation in Engineering & Science Education (CIESE)

- ✓ Conceptualize & develop graduate certificate program consisting of 5 science courses (15 graduate credits) in science
- ✓ CIESE provides 2 professional development (PD) days per year & monthly classroom coaching visits to support implementation of program activities
- ✓ Courses , PD & classroom support visits aim to improve teachers' content & pedagogical knowledge & consequently improve grade 3-8 students' content knowledge & experiences in science & engineering
- ✓ Institutionalize new programs at the lead IHE such that graduate teacher education programs, the number of faculty involved in K-12 STEM programs, the number of S&E undergraduates who pursue teaching certifications & the use of research-based instructional strategies in university-level coursework increase

Partner Schools

- ✓ Recruit teachers & comparison classrooms for the program & research
- ✓ Support teachers in implementation of PISA² activities
- ✓ Co-design the PD programs for teachers
- ✓ Provide data to support students' achievement in science

Teachers

- ✓ Participate in the graduate courses & PD programs
- ✓ Implement program activities with students
- ✓ Provide input in the design of program
- ✓ Monitor students' success & experiences in science & engineering

St. Peter's College

- ✓ Provide graduate level education courses to increase the number of science & engineering undergraduates who pursue teaching certifications

National Science Resources Center (NSRC)

- ✓ Help build leadership capacity among partner school & district administrators to implement a strategic & sustained science education reform agenda

New Jersey Department of Education

- ✓ Provide support & assistance to schools & teachers to implement a strategic & sustained science education reform agenda

Education Development Center, External Evaluator

- ✓ Conduct & monitor evaluation & research activities
- ✓ Contribute to new knowledge on the impact of an integrated STEM approach on teacher & student science learning; motivation & self-efficacy; & on students' acquisition of 21st century skills

Columbia University, Research Partner

- ✓ Employ & assess a methodology, limiting factor analysis, to gauge the program's effectiveness in meeting its long-term objectives in participating districts; this includes looking at the factors that limit or facilitate successes of teachers in changing classroom practice to help students learn

PARTNER SCHOOL DISTRICTS	IHE PARTNERS
Bayonne Board of Education	Columbia University/Teachers College†
Camden City Public Schools**	Stevens Institute of Technology*
Hoboken Public Schools	St. Peter's College (School of Education)
Jersey City Public Schools	**OTHER PARTNERS**
Lakewood School District	National Science Resources Center (NSRC)
Margate City School District	NJ Department of Education
Morris School District**	Education Development Center (EDC)†
Mustard Seed School (private)	
Princeton Regional Schools	
Red Bank Borough Public Schools	
Saddle Brook School District	
West New York School District	

***Core Partner, †Evaluation Partner, *Lead Agency*

CHALLENGES

- Accelerated start-up led to time constraints in course development
- Different pedagogical approaches, teaching philosophy & expectations among STEM faculty & CIESE
- Uneven mathematics & computer technology preparation of teachers grades 3-8
- Varying science curricula, pacing charts, pedagogical focus of participating 12 districts
- Contextualizing engineering within varied science curricula/programs
- Vacancy in co-PI position due to changes at NJ Department of Education
- Transition to new external evaluator in Year 1

In the Physics Laboratory

RESEARCH DESIGN

PISA (Predecessor USED Project)

TEACHERS: 47 teachers attended the PISA teacher institute held in summer 2009 (21 in July, 26 in August) (Year 3 of 3-year program)

Instruments	Summary of Results
• Pre/Post Tests (25 questions; 20 relating to science & science-related mathematics & 5 relating to engineering) • The second instrument was a survey to capture the lessons that teachers in the treatment group implemented & considered to have worked well during the school year	▪ The PISA teachers' post-test scores improved significantly more than the comparison teachers' post-test scores, even after their slightly higher pre-test scores were taken into account ▪ The greatest number of activities used by any PISA teacher was 21, or 81% of the total number of activities; of the 26 activities, 21 were science & 5 were engineering; teachers implemented an average of 14 of the 26 activities. ▪ Since all teachers were exposed to the same lessons in the workshops, implementing these lessons in their classroom played a major role in the increased post-test results ▪ Teachers' content knowledge had an effect on students' post-test scores in science & engineering ▪ The number of engineering activities to which the students were exposed in the classroom was a significant predictor of their science post-test scores ▪ Teachers mentioned in the survey that the science & engineering lessons promoted problem solving, critical thinking, collaboration & communication in their classrooms, which are crucial skills for students who will compete in the global economy of the 21st century

STUDENTS: A total of 1,565 students (796 PISA students & 769 comparison students) took the pre-test at the beginning of the school year (September 2009). All 39 lead PISA teachers & 36 of the 38 comparison teachers returned both tests; therefore, the total number of student tests that could be matched (pre with post) was 1,179 (638 PISA students & 541 comparison students).

Instruments	Summary of Results
Pre/Post Tests (19 question; 14 science & science-related mathematics & 5 engineering; the science questions were taken from the 4th or 5th grade level questions published online by the TIMSS, MOSART & A Private Universe Project; engineering questions were selected from the EiE evaluation questions developed by the Museum of Science, Boston	• PISA students improved significantly more than comparison students did when their slightly lower pre-test scores were taken into account; when the students' pre-test scores were held constant, the treatment students had higher post-test scores (M=9.869) than the comparison students (M=8.282) • If 2 teachers (1 treatment, 1 comparison) had equal post-test scores, the treatment teachers' students were more likely to do well than the comparison teachers' students • The number of activities students were exposed to in the classroom was a statistically significant predictor of their post-test scores • The more activities a teacher performed, the higher the students' post-test scores

SUMMARY

Key Features	PISA	PISA²
Funding Agency	USED MSP	NSF MSP
Funding Years	2007-2010	2010-2015
Participants	50 Teachers ~ 700 Grade 3-5 Students	400 Teachers ~ 87,500 Grade 3-8 Students
Partner Schools	21 schools in Northern NJ	40 schools in NJ
Research Studies	Quasi-experimental	Quasi-experimental
Components of the PD program	▪ 80-hour summer institute ▪ 3 PD days (per school year) ▪ monthly classroom support visits ▪ 124 hours total PD hours	▪ 15-credit hours of graduate coursework ▪ 2 PD days (per school year) ▪ monthly classroom support visits
Goals	▪ improve teachers' content knowledge & pedagogical content knowledge in science & engineering ▪ improve students' content knowledge in science & engineering ▪ develop students' 21st century skills	▪ improve teachers' content knowledge & pedagogical content knowledge in science & engineering ▪ foster improved teacher attitudes & beliefs towards teaching science & engineering ▪ improve students' content knowledge in science & engineering ▪ develop students' 21st century skills ▪ foster students' positive attitudes & beliefs towards science & engineering subjects/careers ▪ promote institutionalization & sustainability

PISA² RESEARCH QUESTIONS

Teachers:

1. Does a project which uses scientific inquiry & the engineering design process (EDP) contribute to an increase in teachers' content knowledge of science & engineering?
2. To what extent do teachers' beliefs & attitudes towards teaching science & engineering change over time?
3. What are teachers' conceptions of 21st Century Skills as they apply to teaching & learning? To what extent do they change over time as a result of instructional interventions?
4. What immediate & contextual factors limit or facilitate a teacher's success in changing classroom practice?

Students:

1. Does a project which uses scientific inquiry & the EDP contribute to an increase in students' content knowledge of science & engineering?
2. Do students improve their 21st Century Skills as a result of the program?

All Partners:

To what extent did the program promote an increase in collaboration & shared vision among partners? (University Faculty; District & Schools; Administrators; Teachers; Students; Parents)

COURSES

Course 1: Fundamental Principles of Physical Science
Course 2: Fundamental Principles of Earth Science
Course 3: Energy Production & Consumption
Course 4: Understanding Global Change
Course 5: Engineering Solutions to the Challenges of Energy & Global Change

Designing rubber band powered cars

Designing bridges

Designing rollercoaster ride

Designing alarm circuits

Designing houses for the 3 little pigs