MDHE Improving Teacher Quality Grants

Final Report
Cycle 4

<table>
<tr><td colspan="2">Date of Submission: 5/25/07</td></tr>
<tr><td colspan="2">Project Title:
PHYSICS FOR ELEMENTARY AND MIDDLE SCHOOL TEACHERS - CONSTRUCTING AN UNDERSTANDING OF PHYSICS - Force, Motion and Mechanical Energy</td></tr>
<tr><td colspan="2">Name of Lead Higher Education Institution:
Rockhurst University</td></tr>
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Abstract/Summary:

Physics for Elementary and Middle School Teachers - Constructing an Understanding of Physics ITG grant program consisted/will consist of summer 2006 (Cycle 4), 2007 and 2008 physics institutes for grades 4 – 8 science and math teachers with four implementation workshops during each subsequent academic year. The primary goals of the three-year project are: 1) to strengthen teachers' conceptual understanding of physical principles (Energy, Force and Motion in Year 1; Energy, Magnetism and Current Electricity in Year 2; Energy, Heat and Light in Year 3) and the associated mathematical concepts and practices ; 2) to assist teachers in developing pedagogical skills to teach these concepts by implementing inquiry-based, hands-on science curricula; and 3) to augment elementary and middle school students' abilities in science as measured through student assessment and standardized tests. Project goals will be realized through collaborative efforts among the physics and science education departments of Rockhurst, the administrators, principals, instructional coaches of targeted school districts, and both in-class and pre-service teachers.

Teachers work in teams in the summer institute to conduct experiments that merge hands-on, guided inquiry instruction with computer technology. Classroom implementation of the content and pedagogy learned is supported through 1) the teachers' development of DESE standard-based curriculum modules using project pedagogy and content, 2) site visits by project staff to collaborative schools during the academic year to support the institute objectives and aid in the use of assessment data to monitor the effectiveness of instruction, and 3) involvement by the targeted schools' principals and administrators to support educational change with the goal of improving student achievement. Additionally, Rockhurst University pre-service science teacher preparation will be strengthened as pre-service teachers participate in the institute, learn content through the constructivist pedagogy, and collaborate with in-class teachers to develop curriculum modules and assist in classroom implementation.

Number of higher education faculty working on grant project: 4

TABLE OF CONTENTS:

Name	T A PpPs	School	EL or MS	District *(Asterisk if high-need)*
Betty Harter	T	Askew	EL	KCMSD*
Cynthia Phillips	T	J.S. Chick	EL	KCMSD*
Sharon Hayes	T	Chester Anderson	MS	KCMSD*
Natalie Lewis	T	Chester Anderson	MS	KCMSD*
Abby Sprau	T	Blenheim	EL	KCMSD*
Tim Burke	T	Nowlin Middle School	MS	KCMSD*
Becky Carlile	T	Raytown S. Middle School	MS	Raytown
Nancy Booth	T	Raytown S. Middle School	MS	Raytown
John Leimer	T	Calvary Lutheran	MS	Kansas City
Sherry Twyman	T	St. Paul's Episcopal	MS	Kansas City
Lee Gruss	T	Notre Dame de Sion	MS	Kansas City
Genie Kane	T	Maple Park Middle	MS	North Kansas City
Amy Malone	T	Gladstone	EL	KCMSD*
Sandra Spoon	T	Lakewood Elementary	EL	North Kansas City
Pam Dixon	T	Thomas Utican Elem	EL	Blue Springs
Lori Bestgen	T	Moreland Ridge MS	EL	Blue Springs
Allison Spencer	T	Voy Spears, Jr. Elem	EL	Blue Springs
Doris Phillips	T	Moreland Ridge MS	MS	Blue Springs
Derrick Hartley	T	Delta Woods	MS	Blue Springs
Nicole Evert	T	Campbell Middle	MS	Lee's Summit
Sharron Rich	T	Campbell Middle	MS	Lee's Summit
Jennifer Morgan	T	Campbell Middle	MS	Lee's Summit
Chris Buehre	T	Pleasant Lea Middle	MS	Lee's Summit
Ken Presley	T	Pleasant Lea Middle	MS	Lee's Summit
Craig Ericks	Ps	Rockhurst University	MS	Graduate student
Alan Staley	Ps	Rockhurst University	EL	Graduate student
Shari Gamache	Ps	Rockhurst University	EL	Graduate student
Kim Franklin	Ps	Rockhurst University	EL	Graduate student
Maegan Neal	Ps	Rockhurst University	EL	undergraduate student
Chris McTighe	Ps	Rockhurst University	EL	Graduate student

Average number of contact hours: 78 hours

Time period over which the contact hours took place: June 2006 – May 2007

Project Activities:

Rockhurst University's Cycle 4 Title II Improving Teacher Quality Grant "Constructing an Understanding of Physics" consisted of an 8 day summer workshop, two fall teacher workshop days, site visits to teachers' classrooms, and a spring follow-up workshop. A constructivist physics curriculum was developed and conducted to help 24 elementary and middle school teachers and 6 pre-service teachers acquire a deeper conceptual understanding of physics concepts in force, motion and mechanical energy and an enhanced pedagogical knowledge of the constructivist model of teaching and learning.

Constructivist modeled instruction acknowledges students' prior beliefs and misconceptions and encourages the students to construct, through an active, student-centered pedagogy, the development of new conceptual physics models. The summer institute format taught content through pedagogy by following the constructivist process of elicitation, development and application activities. The first step was an Elicitation activity where teachers were presented with demonstrations, activities or questions that caused a cognitive dissonance with previously held beliefs. The workshop instructors elicited class responses, remained neutral, and encouraged class discussion. Step two was the Development phase where groups of teachers and pre-service teachers worked through hands-on and computer-interfaced activities designed to question, discover and discuss physics concepts. Step three was the Application phase that consisted of additional activities to aid in the conceptual construction process and help teachers apply their new learning to additional situations and problems. The cycles concluded with a class discussion and consensus and a return to the Elicitation question(s). Following class consensus, institute instructors added in any necessary content through guided instruction in order to act as a tie-up and allow teachers to cement correct scientific thinking.

In the summer institute, teachers worked in teams to conduct experiments using hands-on laboratory equipment and computer simulations to constructively learn physics concepts, as well as to help them develop their understanding of both the nature of science and the use of a constructivist-based pedagogy as required by a standards-based curriculum. The 8-day (64 hours) workshop began with an overview of the PET constructivist pedagogy which emphasized its importance in the learning process. Institute participants then worked through group constructivist activities to develop an understanding of the energy transfer process and how it applies to principles in force and motion. Teachers confronted misconceptions through the elicitation activities, developed new ideas through the development activities, and applied new understanding through a series of application activities. Course instructors tied up activities and helped teachers build physics content knowledge by modeling all instruction through the constructivist pedagogy. The PET curriculum correlated to the DESE "Show-Me" Standards and Missouri GLE's for Science and the Framework for Curriculum Development in Science for force, motion and mechanical energy for grades 4-8.

In the two fall workshops (10 hours), the teachers worked in their groups to

complete the development of a curriculum module, aligned with the Missouri Frameworks, which incorporated PET activities and implemented the principles learned in the institute. Each module was presented to the class and included: 1) an overview of the content to be taught; 2) constructivist, inquiry-based lesson plans and activities; and 3) assessment tools guided by the GLE's and modeled after the MAP test. The goal is to help the teachers develop, over a period of years, a set of physics/physical science constructivist lessons for elementary and middle schools that can be disseminated to teachers and used district and state wide.

Site visits from the Rockhurst faculty supported the implementation of the teachers' modules. Site visit instructors completed the Reformed Teacher Observation Protocal (RTOP) at each observation in order to determine the amount of constructivist teaching by the institute participant. Additionally, site visit instructors helped the teachers with any implementation problems that may have occurred.

A final spring workshop allowed for discussion of the implementation of the module and the use of the constructivist pedagogy in the classroom. Additionally, teachers took a far post-test and were provided with results of their students' pre-post tests.

This project also served to strengthen Rockhurst's science teacher education program through the inclusion of six student teachers who enrolled in the institute as a course to fulfill a university requirement. These pre-service teachers enhanced their content and pedagogical knowledge and benefited from their interactions with the in-class teachers during the workshop. Pre-service teachers continued their constructivist science education through visits to their mentors' classrooms during the academic year.

Each teacher received a Teacher Kit of materials needed to complete workshop activities. These materials allowed the teachers to apply workshop methods immediately in their classrooms, providing students with interesting, hands-on tools to develop, test, and modify their ideas through experimentation and discussion in accordance with the DESE Performance Standards.

Specific institute activities included (PET curriculum):

1) Energy Transfer Activities: A series of activities involving hands-on work and laboratory equipment to build a conceptual foundation for energy transfers. An energy flow diagram was introduced and used throughout the institute so that the concepts of force and motion were tied to, and explained through, energy transfers .

2) Motion Activities: A series of activities involving hands-on work with laboratory equipment (motion sensors, carts, ramps, masses, etc.) to investigate properties of motion. All activities were related to the transfer of energy using the energy flow diagram.

3) Force Activities: A series of activities involving hands-on work with laboratory equipment and computer simulations. The concepts of force and motion as they relate to mechanical energy were developed through hands-on activities, flow diagrams, narratives and class consensus.

State and Project Objectives:

Listed below are the five Missouri objectives of the Title II – Cycle 4 Improving Teacher Quality program and the status of those objectives:

Objective 1: To improve student achievement in the math and science content areas aligned with the project's content focus

Teachers developed, and submitted, a pre/posttest within their curriculum modules (see Objective 4 below) to evaluate their students' current understanding of Force, Motion and Energy. These pretest scores were compared to the students' scores on a similar test at the conclusion of the teachers' developed module to estimate gains in students' understanding of these physical concepts. Aggregate data show that 1166 students (n = 1166) were pre/post tested. The pre-test average percentage was 37% and the post-test average percentage was 70% indicating a 33% percentage gain in content knowledge by the students of the covered physics concepts.

Objective 2: To increase teacher participants' knowledge and understanding of key concepts in targeted math and science content areas as aligned with the project's content focus.

Twenty-four (n = 24) teachers were given both a pre-workshop and post-workshop content exam (320 points) over physics concepts in Force, Motion and Mechanical Energy. The test was designed to test misconceptions. Results show a pre-test average of 53% correct on the test and a post-test average of 87% on the test indicating a 34% gain in content knowledge of the covered physics concepts over the 8 day institute.

At our final spring meeting in May 2007, 22 teachers (n = 22) took a shortened version of the pre/post test given in summer 2006. This test had a maximum score of 40 points. The average percentage correct on this test for these 22 teachers was 77.5%. Although this aggregate value is lower than the post-test average percent correct following the summer institute stated above, analysis of individual scores on the far post test show that the majority of teachers maintained a high percentage correct. The aggregate value appears to have been pulled down a bit by just a few teachers who scored much lower on the far post test. In Cycle 5, we will focus on the retention of concepts and encourage the teachers to perform as well as possible on this far post test.

The Satisfaction Survey administered by MU at the end of the summer institute indicated that 29 out of the 29 responses believed that the emphasis on improving teacher content knowledge during the institute was high (25) or moderate (4).

Objective 3: To improve teachers' pedagogical knowledge and practices that utilize scientifically-based research findings and best practices in inquiry-based instruction.

1. MU administered a pre/post summer institute survey of teachers that asked a variety of questions related to the teachers' current teaching practices. This survey was also administered at the end of the cycle to determine if a shift toward a more positive attitude regarding constructivist pedagogy had occurred, as well as a shift toward incorporating more constructivist pedagogy into the participants' teaching. Results from the pre/post summer institute indicate that 28 out of the 29 responses believed that the emphasis on using inquiry-based/problem-centered teaching during the institute was high (26) or moderate (2).

2. Two faculty on our grant staff, a physics instructor and a math educator, conducted 19 site visits (17 in-class teachers and 2 pre-service teachers) to the teachers' classrooms to observe the implementation of the constructivist pedagogy, to assist with content development and to make suggestions where needed. Upon each visit, the project staff completed a Reformed Teacher Observation Protocol (RTOP) assessment on each classroom teacher in order to assess the degree of constructivist teaching employed in the classroom. Per RTOP research, a minimum score of 50 on this observation instrument indicates a constructivist pedagogy was used in the classroom. The average score for our teachers, as graded by our project staff faculty, was a 73.8 and all teachers scored above a 50. Additionally, each classroom teacher was asked to complete a reflection survey following module completion that asked the teacher to reflect on the use of the constructivist pedagogy **(elicitation, development, consensus, application)** in the teaching of his/her workshop module. The reflection surveys indicated a positive experience with implementation of the teachers' modules. Areas of concern were having enough time for inquiry lessons and problems with technology.

Objective 4: To enhance participants' use of assessment data to monitor the effectiveness of their instruction.

The Satisfaction Survey administered by MU at the end of the summer institute indicated that 29 out of the 29 responses believed that the emphasis on assessing student learning during the institute was high (24) or moderate (5).

During the summer institute and fall workshops, teacher groups developed grade-appropriate curriculum modules that included constructivist lessons and authentic

assessment tools (test and rubric) that model the MAP format and correspond to the Missouri Curriculum Frameworks and GLE's. The assessment component included in the curriculum modules was used by the teachers in their classrooms to monitor their effectiveness of instruction with their students. This data was then used to submit the pre-post student test results as indicated in Objective 1.

These modules are completed and uploaded to Rockhurst University's Constructing an Understanding of Physics website for dissemination to science teachers: http://cte.rockhurst.edu/facultydetail.aspx?pgID=1173

Listed below are the components each group was asked to include in their curriculum module:

- ✓ Major concept(s) to be covered
- ✓ Match to Missouri Standards (http://www.dese.state.mo.us/divimprove/curriculum/index.html)
- ✓ Assessment Tools (traditional and alternative or performance-based)
- ✓ Time required: number of inquiries and class periods in the module
- ✓ Overview: A brief introduction that puts the module lessons in context. It should provide a link between the current lessons and those that precede and follow it and outline what students will do in the lessons.
- ✓ Student Objectives: a list of the things students are expected to accomplish in the module
- ✓ Background: Detailed information relating to the content of the module. This section is intended to provide teachers who are unfamiliar with the lesson content a foundation for answering student questions and facilitating inquiry. The Background section should also contain information about common student misconceptions that relate to the content of the lesson.
- ✓ Materials: A list of materials, presented under appropriate subheadings depending on the nature of the inquiry to be performed (e.g. For Each Student, For Each Group of 4 Students, For the Teacher).
- ✓ Four to Five Lesson Activities: Elicitation Activities used to determine students' prior knowledge, Development Activities, Application Activities
- ✓ Each module provided all information required for teaching the chosen concept in order to encourage and enable the teachers to apply this professional development in their classrooms

In our quest to continue improving our workshop professional development for teachers, our grant program this year included a substantially stronger assessment component. We worked with the teachers in the creation of strong, authentic assessments that tied to the constructivist PET curriculum. For each question asked, teachers created a rubric that would allow for accurate data collection on student knowledge gain as well as areas of confusion that needed additional focus. In addition, based on the advice of 2005 external evaluation formative report, we allowed time daily in the summer workshop for the teachers to process the workshop content learned that day, to work with their groups on their modules,

and to discuss assessment of learned concepts.

Objective 5: To demonstrate a measurable impact on the preparation of pre-service teachers through improvements in math and science content and pedagogy courses.

Six pre-service teachers were accepted to participate in the summer institute and fall physics workshops. These students had to complete an application and submit a recommendation in order to be accepted to a spot in the program. Each pre-service teacher took the course to fulfill their science requirement for the education program at Rockhurst University. The pre-service teachers worked in groups with in-class teachers to complete all activities and develop curriculum modules to be used in the teachers' classrooms. In the fall semester, the pre-service teachers visited their teachers' classrooms and worked with them to implement the developed module. The pre-service teachers received 3.0 credit hours for the summer institute and 1.0 credit hour for the fall classroom module implementation. The pre-.service teachers also took the pre and post content test during the summer institute and received an average pre-test percentage of 49%, an average posttest percentage of 73% with an average gain of 24%.

Five out of the six pre-service teachers were able to visit the teachers' classrooms in the 2006 fall semester and work with them to implement the developed module (one pre-service teacher was student teaching in the fall semester so instead she used it in her own classroom) Each pre-service teacher completed a reflection of his/her experience in the institute and classroom and all indicated the strong value of the constructivist pedagogical method used - both in learning science while taking the workshop class and implementing the curriculum in the teachers' classrooms.

In addition to direct workshop benefits to the six pre-service teachers involved, the grant program has served to improve science and math content and pedagogy courses at Rockhurst through two courses offered during the 2006-7 academic year:

1) PH 2300 Phascination in Physics – a four credit hour course offered by the physics department for the first time in Fall 2005 to non-science majors as a constructivist, inquiry-based class modeled after the summer physics institute curriculum.

2) ED 6501 An Integrated Approach to Teaching Mathematics, Science, Health and Physical Education – a four credit hour course offered by the Education Department in Spring 2007 designed for the Masters in Elementary Education students as a methods course that stresses the application of the constructivist pedagogy in science and math content improvement and curriculum planning.

Dissemination of Project Information:

Interface B Convention – Missouri Department of Education, Tan-Tar-A, Missouri, February, 2007. Jean Barker (Cycle 4 project K-12 instructor) and Donetta Horky (Cycle 3 and Cycle 5 participant) presented a teacher workshop entitled "Using Carts and Motion Detectors to teach Motion and Energy." This was a constructivist physics activity pulled from the institute designed to enhance teachers' conceptual knowledge of motion and its connection to mechanical energy. Approximately 80 teachers attended this workshop. Rockhurst's Title II Improving Teacher Quality Grant was discussed and information about the grant program was disseminated to Missouri teachers.

NSTA National Convention, St. Louis Missouri, March 2007. Allen Constant (Cycle 4 project K-12 instructor) presented a teacher workshop entitled "Motion, Motion, Everywhere . . . . Analysis Anyone?" This workshop was a constructivist physics activity that analyzed motion graphs using constant motion, fan and pull-back cars.

NSTA/SCST National Convention, St. Louis Missouri, March 2007. Nancy Donaldson (project co-PI) presented a paper entitled "Results of a Title II Improving Teacher Quality Grant Program on Constructing an Understanding of Physics." The presentation outlined the current grant project objectives and shared the project results with science educators nationwide. The outcome of this presentation led to a submission/acceptance to the Journal of College Science Teaching on constructivist physics teaching and the time necessary for reform to occur.

Conclusions/Implications:

Data from this Cycle 4 Improving Teacher Quality Grant Program indicate a positive improvement for the teacher participants and the pre-service teachers in both comfort and knowledge in the areas of conceptual physics content and constructivist pedagogical skills. The students' scores indicated a positive gain in content knowledge on physics principles taught using the constructivist pedagogy. Two of Rockhurst's main goals in conducting grant programs are to improve the conceptual content knowledge of the teachers and to encourage the use of the constructivist pedagogy to teach this content in their classrooms. It is our belief that when teachers have a strong content foundation, combined with effective pedagogical skills, they will be able to prepare more powerful lessons, better motivate their students to learn science, and lay the foundation for continued growth.

We continue to evaluate ways in which we can provide additional emphasis on helping the teachers implement their improved content and pedagogical skills in their classroom so as to aid students' achievement. We appreciate the input from the MU Evaluation team and have tried to consistently implement their suggestions. Specifically, for Cycle 4, we used their suggestion to include time in the summer institute for module and pedagogical development. We found this suggestion to be very valuable from an instruction standpoint as well as from the teachers' perspective. In addition, Cycle 4 showed an increased emphasis on the teachers' assessment instruments and a good deal of our pedagogical development time was allotted to the construction of strong, authentic assessments and rubrics. This emphasis on assessment has a dual effect: 1) it strengthens the teachers' implementation of their constructivist module because the assessment helps to guide instruction; and 2) it strengthens the data we receive from the teachers on student achievement if we know that the assessment they use is strong and authentic.

Suggestions from the MU Evaluation team that will be utilized in Cycle 5 are:

1) Increased use of the teachers' nightly reflection questions: we will begin class each day with a discussion of the nightly reflection question(s) to help the teachers clarify the previous day's activities and to clear up misunderstandings and questions. This should provide the PD staff with a strong instructional tool by allowing us to understand how teachers are grasping the concepts each day.
2) Class discussions: MU encouraged self-reflection and partner discussion in addition to the whole class and/or group reflection that we currently emphasize.
3) Group Work: currently, teachers work with their self-selected group – most often from the same school. We will plan to blend some of the groups on occasion so that they can benefit in learning from teachers at other schools. Additionally, we plan to implement cooperative learning strategies to the groups to increase balanced participation.

Cycle 5 Activities (Year 2 of a three year project):

Cycle 5 will begin with a focus on field interactions (magnetic and gravitational) and then continue with a more in-depth study of magnetism and current electricity – again tying all concepts under the umbrella of energy transfer. The curriculum will be constructivist, hands-on, inquiry based and interfaced with the computer. We will be continuing with the PET (Physics for Everyday Curriculum) used in our past two cycles as this curriculum has been very well received by the teachers.

Our cohort of teachers will be essentially the same, with 20 out of 24 of our Cycle 4 teachers returning for Cycle 5. In addition, we will have 4 new teachers who work in the KCMSD (high needs) district and we will have 6 new pre-service teachers from Rockhurst University.

We plan to continue with the approach that has produced success in past cycles and add in suggestions from the MU Evaluation team as outlined above.

Attachments: from website http://cte.rockhurst.edu/facultydetail.aspx?pgID=1173

Teacher Modules:

2006 CPU/PET Workshops -

Teacher Modules

In the summer of 2006, twenty-four science and math teachers from grades 4 - 8 were targeted from metropolitan schools to participate in the grant and study concepts in Force, Motion and Mechanical Energy Transfer. Due to the success of the addition of pre-service teachers in the grant program, six pre-service teachers from the Rockhurst University education department were accepted for grant participation, attended the summer and fall workshops, and worked in groups with the teachers to develop a curriculum module to be implemented in the teachers' classrooms. The pre-service teachers will visit the teachers' classrooms in the fall 2006 semester in order to assist with module implementation.

- Force, Motion and Mechanical Energy Modules
- Graphing Modules

2006 CPU/PET Workshops Modules -

Force, Motion, and Mechanical Energy Transfer (Science)

Grade Level: 3, 4, 5
Title: Go Motion Unit
Participants: Betty Harter, Amy Malone, Cynthia Phillips, Abby Sprau
View project: [Word Document] [pdf]

Grade Level: 4 , 5
Title: Force, Motion, & Energy Transfer Module
Participants: Pam Dixon, Allison Spencer, Sandie Spoon, and Kim Bumpus
View project: [Word Document] [pdf]

Grade Level: 5, 6, 7, 8
Title: PET Adapted Force and Motion Module for Middle School

Participants: Sherry Twyman, Doretta Perna, Lee Gruss, Ruby Grant
View project: [Word Document] [pdf]

Grade Level: 6, 7, 8
Title: Force, Energy, and Motion- PET Adapted Module
Participants: Becky Carlile, Nancy Booth, Tim Burke, Maegan Neal
View project: [Word Document] [pdf]

Grade Level: 6, 7, 8
Title: Force, Motion, and Energy Transfer
Participants: Lori Bestgen, Derrick Hartley, Genie Kane, Doris Phillips
View project: [Word Document] [pdf]

Grade Level: 5, 6, 7, 8
Title: Speed/Graph Module
Participants: Sherry Rich, Jennifer Morgan, Niki Evert, Allen Staley, John Leimer, Ken Presley, Chris Buehre, Craig Ericks
View project: [Word Document] [pdf]

2006 CPU/PET Workshops Modules -

Graphing (Math)

Grade Level: 7
Title: Fairview and Kansas City Middle School of the Arts
Participants: Shari Gamache, Sharon Hayes, Natalie Lewis, Chris McTighe
View project: [Word Document] [pdf