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Kaput Center for
Research and Innovation in STEM Education

200 Mill Rd., Suite 150B
Fairhaven, MA 02719, USA

ANNUAL REPORT FY2018

KAPUT CENTER FOR
RESEARCH AND INNOVATION IN
STEM EDUCATION

June 25, 2018

Foreword

All Academic Institutes and Centers at UMass Dartmouth are required to prepare an annual report for the fiscal year just completed, and this report fulfills this requirement for FY18.

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**UNIVERSITY OF MASSACHUSETTS DARTMOUTH
KAPUT CENTER FOR RESEARCH AND INNOVATION IN
STEM EDUCATION**

The Kaput Center for Research and Innovation in STEM Education is an interdisciplinary University Research Center that conducts innovative research in the teaching and learning of mathematics in all educational contexts. It is an academic Center located administratively with the School of Education in the College of Arts & Sciences.

Chandra Orrill, Ph.D. –Director

EXECUTIVE BOARD AT END OF FY17

Chairperson of the Board: Michael Goodman, Ph.D Associate Professor of Public Policy, UMass Dartmouth Term Expires: 5/18	Marylou T. Clarke, C.A.G.S. <i>Assistant Superintendent of Dartmouth Public Schools (Retired)</i> Term Expires: 05/19	Paul Fredette, President & CTO – Promptus Communications CTO - American Doctors Online Term Expires: 11/18
<i>Beste Güçler, Ph.D.</i> <i>Associate Professor of Mathematics Education, UMass Dartmouth</i> Term Expires: 5/19	Rebecca L. Harrison, B.A. <i>Research Associate, UMass Dartmouth</i> Term Expires: 05/17	Chandra Orrill, Ph.D. Associate Professor of Mathematics Education, UMass Dartmouth Term Expires: 05/17
John Russell, Ph.D. <i>Emeritus Professor of Physics, UMass Dartmouth</i> Term Expires: 05/18	Dave Welty, Ph.D. Chair of STEM, Fairhaven Public Schools Term Expires: 5/18	

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Mission

The Kaput Center for Research and Innovation in STEM Education at the University of Massachusetts Dartmouth was established on March 1st, 2007. The Center was established in the spirit and vision of James J. Kaput, whose innovative thinking and leadership inspired many in the field of mathematics education. The purpose of this Center is to provide a focus and support for sustained investigation of foundational issues in the field of STEM education, issues that will be chosen to enhance and deepen ongoing research by its members and associates. The Center is an interdisciplinary research unit where fundamental problems in STEM education are studied, discussed and analyzed through conferences, interdisciplinary colloquium series, basic research and development, commissioned reports, and think-tank meetings.

This document reports the progress toward the fulfillment of this mission for the period July 1st 2017 to June 30th 2018, which is Fiscal Year 2018. This document was prepared by Dr. Chandra Orrill, Director of the Center.

TABLE OF CONTENTS

Introduction.....	4
Director’s End-of-Year Report FY2018.....	5
Kaput Center Infrastructure	7
Executive Board & Duties.....	7
Advisory Board & Duties	8
Research Scientists, Associates & Staff.....	8
Physical Layout & Equipment	9
Inventory	10
Summary of Fiscal Activity.....	10
Functional Areas of Operation	12
Research & Development.....	12
Symposium & Colloquium Series.....	13
STEM4Girls Girls Day	14
Support PhD Program	14
Research Grant Proposal Activity	15
Funded Proposals.....	15
Proposals Under Review	16
Declined Proposals.....	16
Declined Proposals to Foundations	17
Major Research Publications (2007-2018).....	18
International Collaborations	27
APPENDIX A	28
APPENDIX B	31
APPENDIX C	34

Introduction

The Kaput Center for Research and Innovation in STEM Education at the University of Massachusetts Dartmouth (hereon called the “Kaput Center”) was founded by Professors Blanton, Hegedus and Moreno-Armella of the Department of Mathematics. The Kaput Center grew out of Professor Jim Kaput’s aim of democratizing mathematics for all learners.

President Jack Wilson approved its establishment on February 14th, 2007 and its was officially established by Dr. Anthony Garro, Provost of the University of Massachusetts Dartmouth, on March 1st, 2007.

Dr. Stephen Hegedus, Professor in the Department of Mathematics, was appointed the Center’s first Director by Provost Garro and Chancellor MacCormack.

During the initial period of its establishment (March – June of FY07) the Director and the founding faculty established an Executive Board and External Advisory Board. Projects of the Mathematics Education faculty were transferred to the Center and an agenda for the operation and events of the Center for the upcoming years was established.

In 2014, Professor Hegedus resigned from UMass Dartmouth, leaving the Kaput Center in the hands of Professors Goodman, Güçler, and Orrill serving as Interim Directors while a permanent director was sought. The search for a permanent director for the Kaput Center in FY 2015 was not successful, thus the leadership structure remained the same for FY2016. In FY2017, Professor Walter Stroup joined the leadership team and Professor Goodman stepped into the role of Chairperson of the Executive Board without additional duties. At the end of FY2017, an internal search was conducted and Professor Chandra Orrill was named the Director of the Kaput Center effective July 1, 2017. Professor Goodman has agreed to continue serving in his capacity as Chairperson of the Board.

This report documents the ongoing work of the Kaput Center through FY2018 and new initiatives.

Directors' End-of-Year Report FY2018

I present this annual report that shows the collective work of the people of the Kaput Center: faculty, students, staff, and Executive Board Members. This year has been a positive one in many ways with two main foci. First, I have been working to create clear incentives for faculty to participate in the Kaput Center. Second, we have been working to raise regional awareness of the work we do. To create clear incentives, I considered my own and other faculty members' frustrations in engaging in grant work and identified the most important factor being a lack of support with administrative details. To this end, I was able to create a position for a Grants Support Specialist who also serves as a part-time project manager. The position is partially paid through the Kaput Center and partially through funded projects. The Grants Support Specialist supports faculty in a variety of pre-award and post-award administrative tasks. For pre-award work, this includes writing budgets, securing partner letters, interfacing with the SPA office, and entering materials into Fastlane or other online system. For post-award support, the position provides help with making one-time purchases, paying participants, putting graduate student researchers on payroll, and managing our project credit cards. This relieves the Principle Investigators of some of the particularly tedious aspects of running grants. In addition, the position is written so that projects can hire the Grant Support Specialist as a part-time Project Manager without needing to go through the typical hiring process. To date, we have had two grants take advantage of this feature and all of the PIs have taken advantage of the pre and post award functions. We were extremely fortunate to be able to hire Kym Welty as the first person to hold this position, Kym has a great "can do" attitude and came to us with many of the skills needed to be successful in this position.

The second area of focus was creating more of a presence in our region. As I go to conferences around the world, I am struck by the name recognition people have for the Kaput Center. Almost always, when I introduce myself as the Director of the Kaput Center, I am met with an anecdote about Jim Kaput, a story of what SimCalc has meant to the person, or general enthusiasm about the Center. Yet, when I tell people in the SouthCoast that I am the Director, most of the time, I am greeted with blank stares and asked what the Kaput Center is. It will be an ongoing process to build our brand, but this year we took a number of steps to start that process. First, we have had a presence at many local STEM events including two events hosted by CONNECT and the national SeaPerch Expo held on campus in June. Second, we are rebuilding the Kaput Center website and expect it to go live in July. This has been a 2+ year process with many twists and turns, but we believe that the new site will be easier to maintain, visually inviting, and offer more flexibility for us moving forward. We also created a Facebook page for the Kaput Center and revived the Twitter account. While we are still relatively quiet on social media, our list of followers is growing and includes faculty, staff, and students at UMass Dartmouth; parents interested in STEM programs; local teachers; and members of Jim Kaput's family. One final outreach effort we made was the creation of a newsletter that we intend to publish each semester recapping the major events of the semester, highlighting research happening in the Center, and highlighting people in the Center. The newsletter is written by a

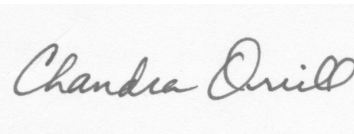
team of Kaput Center personnel including staff, faculty, students, and Executive Board Members. In this way, it includes a variety of voices to describe the work we do.

The Kaput Center has had another successful year for grants. In addition to the sunsetting NSF-funded Teach SouthCoast STEM grant (PI: Witzig), we have three more active grants: Professor Stroup leads a \$1million DRK-12 grant; Professor Kayumova leads an NSF CAREER grant worth \$779,000; and, I lead an NSF-funded DRK-12 grant for \$738,337. We recently received the news that I will be receiving a grant from the Institute for Educational Sciences (U.S. Department of Education). The UMass Dartmouth subaward on the grant is \$237,000 for 4 years. This new grant adds to our portfolio in that it is focused on the creation of online Professional Development around proportions that is supported by a virtual facilitator. The idea is to democratize access to high-quality professional development by creating personalized professional development that is available anytime and anywhere.

We hosted four symposium events this year with a focus on looking at how the four big ideas from Jim Kaput's work have been adopted and moved forward over the first decade of the Center's existence. Those big ideas are: democratizing access to powerful ideas, using technology to support STEM learning, building representational fluency, and bringing forward-looking curriculum reforms to scale. We also hosted the largest STEM4Girls event to date with 192 girls registered and over 135 attending despite a hard Nor'easter hitting the day before the event. We were delighted to welcome Dr. Angela Dorsey from the Jet Propulsion Lab as a keynote speaker and over 30 more people as workshop leaders.

We also used this year as an opportunity to revisit the Center's bylaws. A streamlined version of the bylaws was approved by the Executive Board and submitted to the Dean and the Provost for approval. In the next year, one of our goals is to grow our Executive Board. This year, we bid farewell to longtime board member John Russell, who felt it was time to retire, and in recent years we bid farewell to a few others for various reasons.

As always, the Kaput Center is a reflection of its people. The faculty, staff, and students who work together to create the Center help keep it alive and evolving year after year. For that I remain very grateful and offer my sincerest thanks.



Chandra Orrill
Director

Kaput Center Infrastructure

Executive Board & Duties

The Executive Board consists of the Director of the Kaput Center, ex-officio, and no more than fifteen other individuals who shall be faculty members at an accredited institution of higher education; qualified professional practitioners with a documented record of scholarship or professional experience in education or educational policy, particularly, but not constrained to, STEM education research; or drawn from positions of leadership in the public, non-profit, and private sectors. The Director will invite and accept nominations for members of the Executive Board for review by the Executive Board. All members of the Executive Board agree to execute the mission of the center in collaboration with other Executive Board members and abide by the policy on center operations. A full list of members will always be displayed in the Kaput Center and included in the Annual Report.

The Executive Board convenes quarterly. The Director of the Kaput Center must notify all members of the Executive Board of the time, date, and place of all quarterly meetings at least one week prior to said meetings. A simple majority of the Executive Board shall constitute a quorum. Meetings are run subject to Robert's Rules of Order. The Provost and the Chancellor of the University of Massachusetts Dartmouth as well as the Dean of the College of Arts and Sciences, can attend all Executive Board Meetings, although they are not members of the Executive Board.

The Executive Board exercise the following powers and authority:

- to review the Director's quarterly update on research projects, service agreements, sponsored research agreements, and other activities,
- to review the Director's quarterly statement of the budget for the Center and to make recommendations for expenditures and encumbrances from the budget,
- to approve or reject nominations of individuals for appointment to the Center as Research Associates or Visiting Research Associates,
- to approve or reject nominations of individuals for appointment to the Executive Board,
- to approve or reject the Director's recommendations for creating or discontinuing functional Divisions of the Kaput Center,
- to approve or reject the Director's nominations of individuals for the appointment and removal of Heads of Divisions,
- to review, recommend, and approve any policies governing the Center's operations as specified in the Mission Statement and By-Laws,
- to approve or amend the Director's proposed annual report, financial statement, and proposed budget before it is submitted to the Provost or other officers of the University,
- to approve all recommendations from standing committees of the Executive Board,
- to advise and assist with graduate student recruitment strategies.

A simple majority of those members present and voting shall be sufficient to grant or withhold the approval of the Executive Board on all matters, except as specified elsewhere in the Mission Statement and By-Laws. Membership is for three (3) years and renewable.

Advisory Board & Duties

The Kaput Center is linked to the wider community through an Advisory Board. The Advisory Board shall be composed of individuals, appointed by the Director in consultation with the Executive Board, who are drawn from positions of leadership in the public, non-profit, and private sectors. The Board will assist in setting the Center's research agenda and in developing research resources. The Board will also advise and assist the Director and Executive board in developing strategic plans to achieve its mission that responds to educational need both locally, nationally and internationally in the field of STEM education. The Advisory Board are considered advocates of the Center, promoting the work of the Center and establishing new associations with leaders in STEM education research and innovation.

The Advisory Board has historically been extremely helpful in advising the Director in planning the Center's events and its operation more globally, particularly on realizing the scope and possibilities of how the Center can make an impact over time. Some advisors have also visited and assisted associates of the Center in their R&D programs, and hosted graduate students at their institutions.

Research Scientists, Associates & Staff

As part of the bylaws editing process, we revisited the Research Scientists, Associates, and Staff and decided to simplify the structure for associates of the Center. There are now three primary designations: Research Scientists, Visiting Research Scientists, and Research Assistants. They are described as follows:

a. Research Scientist: (1) a tenured or tenure-track faculty member at the University of Massachusetts Dartmouth, who is developing or executing a research, public service, or educational project under the auspices of the Kaput Center, or (2) a qualified professional practitioner, who is locally developing or executing a research, public service, or educational project under the auspices of the Kaput Center,

b. Visiting Research Scientist: (1) any faculty member at an accredited college or university, who is developing or executing a research, public service, or educational project related to the mission of the Kaput Center and will have a physical presence at the Kaput Center or (2) a qualified professional practitioner, who is developing or executing a research, public service, or educational project related to the mission of the Kaput Center and is visiting the Center. Visiting Research Scientists are expected to make a substantive contribution to the Kaput Center in collaboration with Center faculty and students. Appointment to the position of Visiting Research Scientist requires the approval of the Kaput Center Executive Board.

c. Research Assistant: (1) any PhD student accepted onto the Doctoral Program in STEM Education at the University of Massachusetts Dartmouth who is appointed as a Research Assistant to a Center-based grant-funded project.

These positions are two-year, renewable appointments.

During the creation of the new website, we will be making these changes. The Executive Board agreed to offer all non-UMass Dartmouth partner faculty who no longer have designations as a result of these changes a position on the Kaput Center Advisory Board. This invitation will be in Summer 2018.

Physical Layout & Equipment

At the end of FY14, the Kaput Center space was reduced so that it now occupies approximately 2100 square feet at a rented facility in Fairhaven, MA. In FY2017, we were forced to relinquish our conference room, but were given access to the conference room in the space previously occupied by the Center for Marketing Research. The lease for our current space ended in August 2017. Current plans include leaving the Kaput Center in Fairhaven for the next few years, however, the plans are in constant negotiation.

The Kaput Center has a variety of equipment intended to support the research and outreach mission. This equipment includes:

- Gigabit connectivity within the Center and secure 802.11a/b/g/n wireless connectivity
- Several projectors appropriate for use as needed
- 7-computer Apple Wireless Learning Lab with a suite of mathematical and mathematics educational software (e.g., Mathematica, Maple, Matlab, SPSS, Geometer's Sketchpad®, Cabri, MS Office, Adobe, Macromedia, etc.)
- iPads for use on research projects including 3 purchased in 2018
- 3 Chromebooks for use in research projects purchased in 2018
- HD/DV cameras

As part of the website development, we purchased the <http://kaputcenter.org> URL for five years and will be hosting the website at that location. We also purchased <http://intermath.org> for five years to facilitate the move of the InterMath task set from the University of Georgia to the Kaput Center. This will become a resource for courses and professional development efforts.

In addition to these technical facilities, the Kaput Center has a large library that supplements the Campus library facility and which includes many Mathematics Education journals and periodicals dating back 20+ years. We have access to these resources and a full searchable electronic bibliography of these materials. The Center will continue to add cutting edge, contemporary, and cross-disciplinary literature that is not always available on the main University Campus. The Center's library houses over a thousand books covering areas of: Mathematics Education, Anthropology/Evolutionary Theory, Cognitive Psychology/Science,

Representation theory, Computer Science and Design, Learning Sciences, Linguistics and Discourse Analysis, Complexity Theory, Mathematics, Philosophy, Socio-Cultural Studies, and Quantitative and Qualitative Methodology (over \$20K worth of major Handbooks in this category alone).

Inventory

The Center has a wide range of resources to conduct the work necessary to achieve the goals of its mission. In summary, these include:

- Conducting funded and unfunded (proof-of-concept) research and development programs,
- Provide professional development services (both on-site and on-line) and,
- Host various professional meetings and events throughout the year.

Summary of Fiscal Activity

We report in detail here the Center's main operational budget and not the revenue/cost structure of externally funded grants. Total operational budget for FY15 was \$52,415 with operational expenses of \$65,954. The expenses above the operating budget were covered with Indirect funds. We end the year with \$37,555 left in the Indirect account.

Expense Type	Description	\$
Revenue	University Support (Salaries, Fringe, & Operational Budget)	\$39,009.00
	Indirect Revenue	\$20,610.89
	Indirect Adjustments	-\$7,205.06
	Total Revenue	\$52,414.83
Direct Expenses		
Payroll	Total Payroll FY18	-\$23,792.66
Fringe	Fringe for FY 18	-\$8,858.19
	Total Payroll & Fringe for FY18	-\$32,650.85
Non-Payroll		
Office/Admin Supplies		2093.81
	Total Office & Admin Supplies	-\$2,093.81
Employee Related Expenses	Travel	-\$1,337.60
	Total Employee Related Expenses	-\$1,337.60
Non-Employee Expenses	Travel	-\$4,147.98
	Honoraria	-\$4,500
	Total Non-Employee Expenses	-\$8,647.98
Facility & Operations	Food & Beverage	-\$2,365.15
	T-shirts (STEM4Girls)	-\$2,214.00
	Research Supplies	-\$1,416.65
	Books – NonLibrary	-\$1,584.18
	Technology	-\$3,206.12
	Website/cloud	\$3,217.19
	Waste Removal (Shredding Service)	-\$431.96
	Total Facility & Operations	-\$14,435.25
Printing Expenses	Copier charges	\$1,656.29
	Total Printing Expenses	-\$1,656.29
Conference Misc & Temp Space	STEM4Girls	-\$3,670.85
	Total Conference Misc & Temp Space	-\$3,670.85
Postage & Freight		
	Total Postage & Freight	-\$3.69
Telecom Services Voice		
	Total Telecomm Services Voice	-\$1,255.03
Educational Assistance		\$90.00
Overhead	8% on expenses in Misc account	\$113.04
	Total Non-Payroll	-\$33,303.54
	Total Direct Expenses	-\$65,954.39

Table 2: Revenue & Costs for FY17

Functional Areas of Operation

Research & Development

Addressing Mission Need: Provide a focus and support for sustained investigation of foundational issues in the field of mathematics education ...

The faculty and staff of the Kaput Center and their associates continue to conduct cutting-edge research in mathematics education focusing on the following core areas:

- Enhancing mathematical communication in K-16 classrooms
- Transforming teaching practice across districts
- Addressing the needs of all learners in STEM Education
- Teacher knowledge and teacher professional development
- District-wide improvement of mathematics and science teaching in elementary and middle grades
- Teaching and learning mathematics at the undergraduate level

There were four funded grants in the Kaput Center in FY 18:

Teach SouthCoast STEM. This project was funded by the National Science Foundation and moved to the Kaput Center in FY 2016 under PI Stephen Witzig. The grant includes 21 Master Teaching Fellows and Teaching Fellows. The goals of the project are to (1) deepen educators' STEM content knowledge and instructional practices through content-intensive learning experiences; (2) develop critical 21st Century Skills through active exploration of emerging technologies; and (3) develop participants' teacher leadership skills.

CAREER: Analyzing the Nexus between Advantaged Social Positioning and Science Identity Development Among English Language Learners. This project was funded by the National Science Foundation with a start date of September 2017. This grant to Shakhnoza Kayumova explores how to support students in developing as STEM learners while they are also learning to speak English. The goal of the grant is to better support teachers to support students who are grappling with language acquisition.

Group-Based Cloud Computing for STEM Education. This project was funded by the National Science Foundation DRK-12 program. Walter Stroup leads a four-campus team developing tools that allow students to engage in science and mathematics in the classroom using the collaborative computing power available through cloud-based solutions. This is an exploratory project seeking to demonstrate how group-based learning based in generative design can support learning.

Proportions Playground: A Dynamic World to Support Teachers' Proportional Reasoning. This project, also supported by the National Science Foundation, examines how dynamic environments support teachers in reasoning about proportional situations. This work grew out of Chandra Orrill's CAREER grant in which the researchers noticed that teachers approach the

same mathematics in different ways in dynamic environment than they do using paper and pencil.

Symposium & Colloquium Series

Addressing Mission Need: The Center is an interdisciplinary research unit where fundamental problems in mathematics education will be studied, discussed and analyzed through conferences, interdisciplinary colloquium series ...

To celebrate the tenth anniversary of the Kaput Center, we decided to hold four all-day symposia with researchers who are conducting research that extend the work undertaken by Jim Kaput. Each speaker gave a colloquium talk that was open to the public as well as conducting a research workshop for students, faculty, and executive board members. The first three speakers also conducted a graduate-student only question and answer session. The fourth speaker conducted a hands-on makerspace experience for participants.

Full abstracts of the talks can be found in Appendix B.

From SimCalc to SunBay: Lessons Learned from 25 Years of Research in the Use of Dynamic Representations in Middle School Mathematics Education

Dr. Phil Vahey, SRI International

November 10, 2017

A Research-Based Approach for Improving Pre-Calculus Teaching and Learning

Dr. Marilyn Carlson, Arizona State University

December 1, 2017

Can Young Children Think Algebraically?

Dr. Maria Blanton, TERC

February 21, 2018

The “Making” of a STEM Course

Dr. Jennifer Lacy, Science Teacher – Kansas City, MO

March 30, 2018

All of the Colloquium talks were streamed live on the Kaput Center YouTube channel and have been made available there for future viewing.

STEM4Girls (March 3, 2018)

On Saturday, March 3, 2018, the Kaput Center, hosted the annual STEM4Girls event on the campus of the University of Massachusetts Dartmouth campus. This year, we invited girls in grades 3-8. We had about 138 girls in attendance despite a Nor'easter hitting the night before (192 had registered). The day was begun with a keynote from Dr. Angela Dorsey from the Jet Propulsion Laboratory who stressed the theme of persistence and shared with the girls that they need not choose between career and family as both are possible. Each girl then participated in one or two workshops and we wrapped up the day with an all-woman panel that included representatives from a wide range of STEM careers.



Supporting the PhD Program

Addressing Mission Need: The Center is an interdisciplinary research unit where fundamental problems in mathematics education will be studied ...

Faculty in the Center developed a proposal for a PhD in Mathematics Education that is housed in the STEM department where they are tenured. This program was approved at the April 30th 2009 meeting of the MA Board of Higher Education. The program started in September 2009. The Kaput Center has worked closely with the STEM department offering research opportunities and authentic learning experiences for students through the work that is conducted on a daily basis.

In Spring 2018, the official approval was received to expand the program to focus on STEM Education. For the immediate future, that will be operationalized as science education and mathematics education, but we aim to eventually include engineering education. The Kaput Center will continue its role in supporting the Ph.D. program.

Grant Proposal Activity

Funded Proposals

Title: Advancing Middle School Teachers' Understanding of Proportional Reasoning for Teaching

PI: Yasemine Copur-Gencturk

Subaward PI: Chandra Orrill (PI on UMassD Subaward)

Co-PIs: Benjamin Nye (USC), Allan Cohen (UGA)

Funding Agency: Institute for Educational Sciences

Amount Requested:

UMassD Amount Requested: \$237,413

Project Dates: 7/1/18-6/30/22

Title: CAREER: Analyzing the Nexus between Advantaged Social Positioning and Science Identity Development Among English Language Learners

PI: Shakhnoza Kayumova

Funding Agency: National Science Foundation, CAREER program

Amount: \$779,000

Project Dates: 2017-2022

Title: Group-Based Cloud Computing for STEM Education

PI: Walter Stroup

Co-PI: Corey Brady (Vanderbilt U), Anthony Petrosino (UT-Austin), and Uri Wilensky (Northwestern U)

Funding Agency: National Science Foundation (DRK-12)

Amount: \$1,045,549

Project Dates: 9/2016-8/2019

Title: Proportions Playground: A Dynamic World to Support Teachers' Proportional Reasoning

PI: Chandra Orrill

Funding Agency: National Science Foundation (DRK-12)

Amount: \$783,337

Project Dates: 9/1/2016-2/28/19

Title: TEACH! SouthCoast STEM

PI: Stephen Witzig

CoPI: Tesfay Meresi

Funding Agency: National Science Foundation

Funds Received: \$2,867,243

Project Dates: October 1, 2011 - September 30, 2017

Proposals Under Review

Title: Collaborative Change Agents: Identifying Barriers and Resources to Promoting Pathways to Educational Attainment through Community Based Participatory Research

PI: Shakhnoza Kayumova

Co-PI: Chris Cipriano (Psychology)

Funding Agency: Corporation for National Community Service

Amount Requested: \$94,609

Project Dates: 9/1/2018 – 8/31/2020

Title: Usable Measures of Teacher Understanding: Exploring Diagnostic Models and Topic Analysis as Tools for Assessing Proportional Reasoning for Teaching

PI: Yasemine Copur-Gencturk (Univ of Southern CA)

Subaward PI: Chandra Orrill (PI on UMassD Subaward)

Co-PIs: Allan Cohen (Univ of Georgia) & Jonathan Templin (Univ of Kansas)

Funding Agency: National Science Foundation

Amount Requested:

UMassD Amount Requested: \$377,973

Project Dates: 6/1/18-5/31/22

Title: Integrating Computing in Chemistry Classrooms (iC3)

Co-PI: Walter Stroup

Funding Agency: National Science Foundation DRL - STEM + Computing (STEM+C) Program

Amount Requested: \$1,249,891 to UT Austin with \$215,209 Subaward to UMassD

Title: Online Professional Learning for Teachers: Teachers' Mathematical Knowledge and Reflection as a Basis for Improving Practice

PI: Yasemine Copur-Gencturk (Univ of Southern CA)

Subaward PI: Chandra Orrill (PI on UMassD Subaward)

Co-PIs: Benjamin Nye (USC)

Funding Agency: National Science Foundation

Amount Requested:

UMassD Amount Requested: \$419,742

Project Dates: 6/1/18-5/31/22

Declined Proposals

Title: Master Teach! SouthCoast STEM

PI: Stephen Witzig

Co-PIs: Shakhnoza Kayumova, Chandra Orrill, Jay Wang

Funding Agency: National Science Foundation

Amount Requested: \$1,416,164

Project Dates: 6/18-5/23

Title: Exploratory foundations for STEM Learning: A First Step in the 21st Century Assessment Project

PI: Chandra Orrill

Co-PIs: Stephen Witzig & Allan Cohen (UGA)

Funding Agency: National Science Foundation

Amount Requested: \$1,717,416

Project Dates: 7/1/18-6/30/23

Unfunded Requests to Foundations

Title: Making Maker Mainstream

PI: Chandra Orrill

Co-PI: Shakhnoza Kayumova

Funding Agency: Boston Scientific

Date Submitted: 8/15/17

Duration: 1 year

Amount Requested: \$36,000

Title: Making Maker Mainstream

PI: Chandra Orrill

Co-PI: Shakhnoza Kayumova

Funding Agency: Toyota Foundation

Date Submitted: 8/15/17

Duration: 1 year

Amount Requested: \$122,066

Publications of the Kaput Center (2009-2015)

2009

- Hegedus, S. J., & Moreno-Armella, L. (Eds.) (2009). Transforming Mathematics Education through the Use of Dynamic Mathematics Technology. *Special issue of ZDM: The International Journal on Mathematics Education*, August 2009, Vol. 41, Issue 4.
- Sriraman, B., & English, L. (Eds.) (2009). *Theories of Mathematics Education: Seeking New Frontiers*. New York: Springer.
- Stylianou, D. A., Blanton, M. L., & Knuth, E. J. (Eds.) (2009). *Teaching and Learning Proof Across the Grades: A K-16 Perspective*. New York/Washington, DC: Routledge/National Council of Teachers of Mathematics.
- Tapper, J. (2009, August). Evaluating Teacher Perceptions of the SimCalc Connected MathWorlds Intervention (Report). Hadley, MA: UMass Donahue Institute.

2010

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- **Introduction: Major Themes, Technologies, and Timeline**
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- **From Static to Dynamic Mathematics: Historical and Representational Perspectives**
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- **Intersecting Representation and Communication Infrastructures**
Stephen Hegedus and Luis Moreno-Armella
- **Reflections on Significant Developments in Designing SimCalc Software**
James Burke, Stephen Hegedus, and Ryan Robidoux
- **SimCalc and the Networked Classroom**
Corey Brady, Tobin White, Sarah Davis, and Stephen Hegedus
- **Learning and Participation in High School Classrooms**
Sara Dalton and Stephen Hegedus
- **Impact of Classroom Connectivity on Learning and Participation**
Stephen Hegedus, Luis Moreno-Armella, Sara Dalton, Arden Brookstein, and John Tapper
- **Connection Making: Capitalizing on the Affordances of Dynamic Representations Through Mathematically Relevant Questioning**
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International Collaborations

The Directors have continued to explore potential relationships with institutions in various countries. These have led to MOUs being established as Partnership Agreements between the University of Massachusetts Dartmouth and the following institutions:

- CINEVESTAV, Mexico City, Mexico
- Tecnológico de Monterrey, Monterrey, Mexico
- UNIBAN, São Paulo, Brazil
- University of Cyprus, Cyprus
- Queensland University of Technology, Australia

The most recent MOU was signed with Queensland University of Technology, Australia in July 2010. MOUs with CINEVESTAV, Mexico, Tec de Monterrey, Mexico, UNIBAN, Brazil and University of Cyprus, Cyprus were signed during the Showcase Event on October 8th 2009.

These MOUs secure various exchanges to enhance the collaborative educational and research missions of our institutions. They focus on student exchanges in our PhD program, faculty exchanges for the purpose of sabbatical or a focused study, and open exchange of ideas and prior work to develop R&D proposal.

View full MOUs at: <http://www.kaputcenter.umassd.edu/news/index.php?path=localglobal/>

APPENDIX A

Advisory Board

ADVISORY BOARD

Advisors are not members of the Executive Board, and do not necessarily have associations with the Center, although that is possible. The Center has a 108-person international and interdisciplinary advisory board, which consists of the following members:

AUSTRALIA

Lyn English - *Queensland University of Technology*

BRAZIL

Tânia Maria Mendonça Campos - *UNIBAN São Paulo*
Ubiratan D'Ambrosio
Lulu Healy - *UNIBAN São Paulo*
Rosana Nogueira de Lima - *UNIBAN São Paulo*

CANADA

Nathalie Sinclair - *Simon Fraser University*

CYPRUS

Constantinos Christou - *University of Cyprus*
Nicholas G. Mousoulides - *University of Cyprus*
Demetra Pitta-Pantazi - *University of Cyprus*

FRANCE

Nicolas Balacheff - *Laboratoire Leibniz*
Raymond Duval
Colette Laborde - *Equipe IAM*
Jean-Marie Laborde - *Cabrilog*

GERMANY

Michael Otte - *Bielefeld University*
Falk Seeger - *Bielefeld University*

GREECE

Chronis Kynigos - *University of Athens*
Joanna Mamona-Downs - *University of Patras*

ISRAEL

Tommy Dreyfus - *Tel Aviv University*
Ted Eisenberg - *Ben Gurion University*
Ana Sfard - *University of Haifa*
Dina Tirosh - *Tel Aviv University*
Pessia Tsamir - *Tel Aviv University*
Shlomo Vinner - *Ben Gurion University*
Michal Yerushalmy - *University of Haifa*

ITALY

Ferinando Arzarello - *Università di Torino*
Maria Allesandra Mariotti - *Università di Siena*

MEXICO

Teresa Rojano - *ILSE*
Patricia Salinas - *Tecnológico de Monterrey*

SINGAPORE

Sarah Davis - *National Institute of Education*
Chee-Kit Looi - *National Institute of Education*

SWEDEN

Per Nilsson - *Linnaeus University*
Häkan Sollervall - *Linnaeus University*

SWITZERLAND

Christof Weber - *FHNW*

UNITED KINGDOM

Celia Hoyles - *University of London*
Barbara Jaworski - *Loughborough University*
Keith Jones - *University of Southampton*
John Mason - *Open University*
Richard Noss - *London Knowledge Lab*
David Tall - *University of Warwick*

USA

Nancy Ares - *University of Rochester*
Yaneer Bar-Yam - *New England Complex Systems Institute*
Hyman Bass - *Michigan State University*
Corey Brady - *Northwestern University*
David Carraher - *TERC*
Allan Cohen - *University of Georgia*
Jere Confrey - *North Carolina State University*
Al Cuoco - *Educational Development Center*
Chris Dede - *Harvard University*
William Finzer - *KCP Technologies*
Megan Franke - *University of California, Los Angeles*
Paul Goldenberg - *Educational Development*

Center

Gerald Goldin - *Rutgers University*

Charles Goodwin - *University of California, Los Angeles*

Rogers Hall - *Vanderbilt University*

Eric Hamilton - *United States Air Force Academy*

Guershon Harel - *University of California, San Diego*

Steve Harrison - *Virginia Tech*

Eric Heller - *UMass Donahue Institute*

Andrew Izsák - *University of Georgia*

Nicholas Jackiw - *KCP Technologies*

David Kirshner - *Louisiana State University*

Eric Knuth - *University of Wisconsin, Madison*

Cliff Konold - *University of Massachusetts Amherst*

Richard Lesh - *University of Indiana*

Marcia Linn - *University of California, Berkeley*

Joanne Lobato - *San Diego State University*

Fred Martin - *University of Massachusetts Lowell*

James Middleton - *Arizona State University*

Ricardo Nemirovsky - *San Diego State University*

João Paraskeva - *University of Massachusetts Dartmouth*

William Penuel - *SRI International*

Norma Presmeg - *Illinois State University*

Steve Rasmussen - *KCP Technologies*

Jeremy Roschelle – *Digital Promise*

Nora Sabelli - *SRI International*

Adalira Sáenz-Ludlow - *University of North Carolina, Charlotte*

Deborah Schifter - *Educational Development Center*

Analucia Schliemann - *Tufts University*

Roberta Schorr - *Rutgers University*

Judah Schwartz - *Tufts University*

Annie Selden - *New Mexico State University*

John Selden - *New Mexico State University*

David Williamson Shaffer - *University of Wisconsin, Madison*

Finbarr Sloane - *Arizona State University*

Judith Sowder - *San Diego State University*

Denise S. Spangler - *University of Georgia*

Bharath Sriraman - *University of Montana*

Walter Stroup - *University of Texas, Austin*

Despina Stylianou - *City College of New York*

John Tapper - *University of Hartford*

Deborah Tatar - *Virginia Tech*

Jonathan Templin - *University of Georgia*

Phil Vahey - *SRI International*

Keith Weber - *Rutgers University*

APPENDIX B

Abstracts of Symposium & Colloquium Series

**SYMPOSIUM & COLLOQUIUM SERIES
(2017-2018)**

From SimCalc to SunBay: Lessons Learned from 25 Years of Research in the Use of Dynamic Representations in Middle School Mathematics Education

**Dr. Phil Vahey, SRI International
November 10, 2017**

Abstract:

In this presentation I will discuss lessons learned from over two decades of research in dynamic representations as enacted in, and then influenced by, the SimCalc project. As the research expanded from small design studies to larger implementation studies and, most recently, to a large-scale randomized control trial, different needs and design considerations came into the foreground. These considerations included the design of technology, the design of curriculum materials, the design and implementation of teacher professional development, and the interaction with different stakeholders and accountability policies. As the research expanded we also developed material for new content areas, which necessitated the design of new dynamic representations. Geographical considerations were also important, and in the talk I will focus on studies that took place in Texas, Florida, and England, and how those locations influenced the design and implementation. I will report on findings across a variety of aspects of the project, including student learning, teacher learning, classroom implementation, sustainable use of the materials beyond the research project, and potentially fruitful areas for future research.

A Research-Based Approach for Improving Pre-Calculus Teaching and Learning

**Dr. Marilyn Carlson, Arizona State University
December 1, 2017**

Abstract:

The function concept is a central idea of pre-calculus and beginning calculus and is used for modeling in the sciences and engineering, yet many students complete courses in pre-calculus and calculus with weak understandings of this concept. Students who are unable to construct meaningful function formulas to relate two varying quantities have little chance of responding to novel applied problems, or understanding key ideas of calculus such as derivative, accumulation and the Fundamental Theorem of Calculus. I will share data that reveals how students might construct these and other critical reasoning abilities and understandings for learning calculus. I will share the research developed Pathways Pre-calculus student materials and teacher resources that provide the context for this research, and are resulting in large gains in student learning of the function concept and other foundational ideas for learning calculus. Results from using Pathways materials at 8 large universities will be shared and contrasted with other popular approaches to teaching pre-calculus mathematics.

Can Young Children Think Algebraically?

Dr. Maria Blanton, TERC

February 21, 2018

Abstract:

Since Jim Kaput (and others) began advocating over two decades ago that teaching and learning algebra needed to begin in elementary grades, the national discourse on school algebra has shifted significantly, resulting in recent learning standards that codify this approach in elementary grades mathematics. But what is the evidence that this approach is valid? Can children in elementary grades think algebraically? In Project LEAP, our goal has been to build on Kaput's algebra framework to design a broad curricular approach to algebra instruction in elementary grades that examines these critical questions. In this presentation, I will explore our evidence for the nature of children's algebraic thinking across Grades K – 5. Our findings, along with the curricular approach that gives rise to them, help build out Kaput's vision of early algebra and his desire to "democratize access" to mathematics for all students.

The "Making" of a STEM Course

Dr. Jennifer Lacy, Science Teacher – Kansas City, MO

March 30, 2018

Abstract:

This presentation examines making and design-based STEM education in a high school makerspace. It focuses on how the design and implementation of a Fab Lab learning environment and curriculum can affect how instructors and students see themselves engaging in STEM. While there is research examining design-based STEM education in informal and formal learning environments, we know little about how K-12 teachers define STEM in making activities when no university or museum partnership exists. This talk will demonstrate how a high school Fab Lab relied on artifacts and rhetoric symbolic of science and STEM to set itself apart from traditional design-based courses like woodworking, and how the credibility and status of STEM allowed the Fab Lab to attract public and private donors and students on the advanced placement coursework path. This talk will discuss the need for more research on what STEM learning should look like in design-based, maker education, academic tracking, and advice for practicing teachers interested in making and creating a makerspace in their school.

APPENDIX C

Kaput Center Newsletter

STEM-ester in Review

Kaput Center Newsletter

Welcome

Welcome to the new Kaput Center newsletter. We aim to send out a newsletter twice each year to keep everyone updated on the work of the Kaput Center. If there are features you'd like to see, please let us know! You can always email us at kaputcenter@umassd.edu

New People

The Kaput Center is delighted to welcome Kym Welty as a Grant Support Specialist and project manager. Kym brings much appreciated experience with UMass Dartmouth systems and processes as well as a service-oriented attitude.

New Website

The Kaput Center is getting a new website! Set to launch at the end of July, the new website will be located at <http://kaputcenter.org>



STEM₄Girls

By: Kimberly Welty, Grants Support Specialist

On March 3, 2018, the Kaput Center for Research and Innovation in STEM Education held its 7th annual STEM outreach event called "STEM₄Girls Day" at the University of Massachusetts Dartmouth. This free event was open to all girls grades 3-8 who wanted to learn more about and engage in Science, Technology, Engineering and Mathematics (STEM). Over 190 girls from the Greater New Bedford area registered and over 130 attended despite the SouthCoast being hit by a strong Nor'easter the day before the event. Our keynote speaker, Dr. Angela Dorsey from NASA's Jet Propulsion Lab, kicked off the program. Her message to the young women in the audience stressed the importance of perseverance. She also wanted to dispel the notion that girls who enter STEM fields of study can't have families. Instead, she said "you can have a career in STEM and still be a mom."

(STEM4Girls Continued)

We hosted 16 STEM workshops, led by experts who volunteered their time, for the girls to participate in. Presenters included UMass Dartmouth faculty and graduate students; local middle and high school teachers from Fairhaven, Fall River and New Bedford; and personnel from other STEM-related organizations. The day's activities were supported by over 40 volunteers from help of our volunteers who included UMass Dartmouth students from TANGENT, Phi Sigma Sigma, Society of Women Engineers, Women in Computer Science, and the Biology Association as well as other people who wanted to help out.

UMass Dartmouth Kaput Center Director Chandra Orrill noted the program's purpose is to make STEM more enticing for girls. "The goal is to engage them in seeing that STEM is fun as well learning some of the content of STEM," Orrill said. "What the research shows us is between fourth and eighth grade, girls tend to lose interest in pursuing science and math courses, which locks them out of pursuing STEM careers later." Women held 47 percent of all jobs in America in 2015, but only 24 percent were in a STEM fields, according to the United States Department of Commerce. Orrill said getting girls into STEM fields is also important for equalizing the workforce and perspective. "If we want to see a more equal workforce this is the age we have to grab their attention," Orrill said. "Both men and women live in the world and if we want to improve everybody's lives then we need to have people from all different perspectives contributing to improving everyone's lives."



Dr. Jen Lacy Symposium

By: Paul Fredette, Executive Board Member

I attended the afternoon workshop led by Dr. Lacy and presentation of her research on the implementation of and experience observing the use of a well-funded high school Maker facility.

The workshop was a group experience for each participant to become a maker using simple craft materials to illustrate the concept of *balance* and how it might be used to express concepts in mathematics. Participants were educators and some children of the Kaput staff. The lack of directions provided a challenge that allowed various independent expressions of creativity.

For my part, I picked up some glue, popsicle sticks, cups, clay and straws. This started as a primitive tool for measuring weights relative to each other. Others started in this direction and spent more time creating a more elaborate implementation. The plan I formulated was to create a unit mass of clay that could be duplicated by using the balance by matching the weight. Not spending more time on the

balance itself led to limitations that other implementations did not have. This was a result that the group was able to achieve that individual efforts may not have explored.

Other participants took very different approaches. One construction was natural scene with trees and plants that were in balance with each other in the environment. One thing that surprised me was a teacher that created an arrow out of Chenille stems. The arrow was used as a pointer to describe the elements of her creation. Quite clever.

The workshop was followed by Dr. Lacy's research talk about one school's recently created Maker Space. Her

observations showed a lack of conceptual learning as students engaged with the latest tools in contrast to the more traditional experiences of "shop" and art. Specifically, the use of computer-based tools became procedural in a somewhat sterile environment of white space and quiet. This was the criteria for the design of the space with the stated goal allowing creativity by removing distractions.

The 3D printing capability was typically used to print objects found on the internet versus students designing them from scratch. The Maker Space faculty believed machine created items were more accurate than shop made items, even when this was clearly not the case as sometimes rough surfaces needed to be processed in a shop to make them precisely match the desired dimensions and aesthetics. Student comments illustrated the deeper learning that occurred when both modes of "making" were employed. The net result was that what seemed obvious about how the latest and best "tech" stuff would enhance learning was not the magic recipe for creativity or Maker Space implementation.



Dr. Maria Blanton Symposium

By: James Burke, Postdoctoral Fellow

In February, we welcomed Dr. Maria Blanton to talk about her research on the capabilities of young students to engage in algebraic thinking. Dr. Blanton is a Senior Scientist at TERC in Cambridge, MA. Her visit was especially significant considering this year's theme revisiting the research interests and contributions of Dr. Kaput and seeing how his legacy has continued. Dr. Blanton worked with Jim Kaput on early algebra research when she was a Professor of Mathematics Education at UMass Dartmouth.

During her visit to the Kaput Center, students and faculty met with Dr. Blanton to discuss the question of whether students in the early grades can think algebraically, and if so what impact might a curriculum in algebraic thinking have on students' mathematical understanding and readiness for algebra in the middle grades.

Dr. Blanton's colloquium presentation on her research, including the work of Project LEAP (Learning through an Early Algebra Progression). Algebra, as Jim Kaput saw it, was not merely the manipulation of symbols ("factoring $x^2 - 4$ until it comes out your ears.") Rather, the algebraic thinking that involves spotting, expressing, and comparing patterns. Project LEAP views algebra through Kaput's framework of four practices across three content domains. Students think algebraically when engaging in generalizing, representing, justifying, and reasoning with mathematical structure and relationships. This occurs in domains of generalizing arithmetic, functional thinking and working with equations, equalities, and expressions.

Dr. Blanton shared promising results of LEAP 3's interventions using a curriculum of algebraic thinking in the early grades. Students who tested similarly before the intervention showed increased gains in performance at every later point in time,

through 3rd and 4th grade (with 5th-grade results yet to come). This study led by a randomized pool of teachers showed that early algebra could have a significant impact. However, that impact was less than the result measured when researchers led the intervention, leading to questions about how we support teachers better in implementing innovative curriculum with fidelity.

Dr. Blanton reminded us of Jim Kaput's tenacious nature when investigating a problem, which she saw as a particular virtue that applies to the pursuit of knowledge and building a career in mathematics education research. Maria recommended that researchers consider sticking with a problem of interest rather than sampling many questions. Despite expected setbacks and rejections, slowly, methodically, developing an agenda would yield eventual payoffs in work. This message and the foundations that Jim provided encourage us to build, using what we know about what students can achieve to push against the boundaries of what we commonly expect students to know in mathematics.



Faculty Spotlight: Dr. Stephen Witzig

By: Jinsook Park, Graduate Research Assistant

Stephen Witzig, a Science Educator at UMass Dartmouth, currently serves as the principal investigator on the \$2.86 million project funded by the National Science Foundation's Robert Noyce Teacher Scholarship Program to implement the Teaching Fellowship/Master Teaching Fellowship Program, known as "TEACH! SouthCoast STEM". UMass Dartmouth and its partners are preparing 20 STEM Teaching Fellows (TFs) and Master Teaching Fellows (MTFs) as STEM educators for the middle and secondary schools of Fall River, New Bedford, and Wareham, MA. The project prepares STEM teacher leaders by focusing on three major strands: (1) educators deepen STEM content knowledge and instructional practices through myriad content-intensive learning experiences; (2) educators develop critical 21st Century skills through the active exploration of emerging technologies in STEM education; and (3) educators develop teacher leadership skills via a collaborative approach, based on a proven model that utilizes peer-coaching, mentoring, and professional learning communities.



Dr. Witzig's research interests are science teacher knowledge and how teachers' experience shapes their knowledge development. The science teacher knowledge construct that is the focus of his research combines science content knowledge and pedagogical knowledge together into what is known as pedagogical content knowledge, or PCK, – craft knowledge that is unique to science teachers. The PCK construct also includes science teacher orientations – teachers' beliefs, goals, and purposes towards teaching science. These are not static and develop over time with experience both in and out of the classroom. Dr. Witzig's research has included participants from his TEACH! SouthCoast STEM grant as well as teachers from his graduate level science education courses.

This summer, he is teaching two courses for science teachers. These courses are titled "Socioscientific Issues for Secondary Science Educators" and "Science Teaching & Learning in Informal Contexts for Secondary Science Educators." Both of these courses include classroom and field-based experiences for middle and high school science teachers that will link scientific learning standards from Massachusetts State Curriculum Frameworks to the local environment. The Socioscientific Issues based course focuses on a new approach to teaching science that involves teaching science through social and political issues where the issue is introduced up front and has a substantive connection to science (i.e. green energy, genetically modified organisms, etc.). The informal science learning course will leverage experiences that teachers can draw from in visiting local museums, zoos, aquariums, nature centers, etc., as places for teachers to engage their students in STEM learning. "So we will go to the sites for informal learning and have teachers become inspired with how to interface with those segments of informal learning to enhance what they are already doing in their classroom."

Grant Spotlight: Girl Power in Making

By: Kym Welty, Grants Support Specialist

This project, funded by the University of Massachusetts Dartmouth, was led by Prof. Shakhnoza Kayumova. The goal of this project was to conduct research to support a proof of concept by designing and implementing socially and culturally mediated Makerspaces approach to coding and robotics in the context of science curriculum which aims at understanding how to support and empower girls' participation and identity development in STEM disciplines. Prof. Kayumova's team consisted of other faculty, graduate and undergraduate students from STEM Education & Teacher Development, Computer Science and Engineering. Prof. Kayumova met with district personnel to select two middle school grade science classrooms. With assistance from UMass Dartmouth professors and students, as well as Makerspace, science and technology consultants from local public schools, Prof. Kayumova developed classroom lesson plans using Bristlebots, aligned these lessons plans to the curriculum standards and then facilitated these activities with middle school students over a six-day period in the two chosen classrooms. She was able to assess students' attitudes about science identity, attitude and motivation both pre- and post-intervention using surveys. Students participated in interviews and classroom activities were videotaped. Going forward, Prof. Kayumova plans to review the data from the surveys, videotapes and interviews to put together professional development that will be delivered during the Fall 2018 semester.



Breaking News: STEM Education Ph.D. Approved!

On June 19, 2018, the Board of Higher Education approved the new STEM Education Ph.D. program for UMass Dartmouth. This program builds on our successful Mathematics Education Ph.D. program to include Science Education and, eventually, Engineering Education. Stay tuned for upcoming programming in support of the new STEM Education Ph.D. program. If you are interested in learning more about the program, please contact the Graduate Program Coordinator, Dr. Karen Terrell, at kterrell@umassd.edu.

Upcoming Events

Visit Kaput Center personnel at Educating for the Future: Practices - Programs - Partnerships on August 15 at Bridgewater State University! More info available here: <http://www.connectsemass.org/stem/>