Abstract Title Page *Not included in page count.*

Title: "Evaluation, Integration and Institutionalization of Initiatives to Enhance STEM Student Success"

Authors and Affiliations:

Lisa Dickson, Assistant Professor, Department of Economics, University of Maryland, Baltimore County (UMBC), ldickson@umbc.edu

Marv Mandell, Co-PI, Professor, Department of Public Policy, University of Maryland, Baltimore County (UMBC), mandell@umbc.edu

Kenneth Maton, Professor, Department of Psychology, University of Maryland, Baltimore County (UMBC), maton@umbc.edu

Dave Marcotte, Professor, Department of Public Policy, University of Maryland, Baltimore County (UMBC), marcotte@umbc.edu

Philip Rous, PI, Provost and Senior Vice President, University of Maryland, Baltimore County (UMBC), rous@umbc.edu

Patrice McDermott, Co-PI, Vice Provost for Faculty Affairs, University of Maryland, Baltimore County (UMBC), mcdermot@umbc.edu

Janet Rutledge, Co-PI, Dean and Vice Provost for Graduate Education, University of Maryland, Baltimore County (UMBC), jrutledge@umbc.edu

William R. LaCourse, Co-PI, Dean of the College of Natural and Mathematical Sciences, University of Maryland, Baltimore County (UMBC), lacourse@umbc.edu

Kathy Lee Sutphin, Director of iCubed@UMBC and Assistant Dean for Academic Affairs, University of Maryland, Baltimore County (UMBC), sutphin@umbc.edu

****

The research would not be possible without extensive support from UMBC and the many individuals who are dedicating their time to the iCubed@UMBC project. This project, a five-year investigation into STEM student success initiatives that is using randomized control trial methodology, is being funded by a grant from the National Science Foundation under NSF Project Number 1038170, which was awarded in 2010.

Contact email: ldickson@umbc.edu

Abstract Body *Limit 4 pages single-spaced.*

Background / Context: *Description of prior research and its intellectual context.*

Many researchers, policymakers, and university administrators have called for more students to major in Science, Technology, Engineering and Mathematics (STEM) fields to address the critical need for a diverse and technically skilled workforce that is prepared to address national problems and educate its future STEM leaders. One argument for increasing the number of students graduating with STEM degrees is that by increasing the number of students with these degrees that we can increase economic growth. One of the questions facing the nation is how best to increase the number of students obtaining degrees in STEM fields. The University of Maryland, Baltimore County (UMBC) received support from the National Science Foundation (NSF) to comprehensively investigate cost effective and scalable strategies to increase the number of students graduating with STEM degrees. UMBC is known for its successful scholarship programs and for increasing the number of students who successfully complete STEM degrees and pursue graduate and professional degrees. UMBC's Meyerhoff Scholarship Program has been recognized as a national model for increasing diversity among future leaders in science and engineering. The programs, as currently administered, can impact a limited number of students due the cost. Also, it is unclear as to what individual facets of these programs matter most for student retention and graduation.

Purpose / Objective / Research Question / Focus of Study: *Description of the focus of the research.*

The project's primary purpose is to identify techniques that significantly impact retention and graduation rates among students who intend to major in STEM disciplines, to verify the estimates of these impacts through careful analysis, and to assess all costs relative to the effectiveness of these interventions. UMBC's goal in the identification and application of techniques that have both high impact and low net costs will help us to better support its students as the project expands best practices that broaden participation and increase STEM graduation and retention rates. By conducting random assignment of students to interventions, we can evaluate the causal impacts of the interventions. Another component of the study is to evaluate the cost-effectiveness of these interventions. While it may be useful to know for example that faculty mentoring is critically important to student success, it is also important to know how costly an intervention would be to scale to all students who enter UMBC. Part of our analysis focuses on the cost-effectiveness of these interventions so as to guide university administrators on how best to implement programs that can impact the most students at the lowest cost.

Setting: *Description of the research location.* (May not be applicable for Methods submissions)

The research location is the University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, Maryland 21250.

Population / Participants / Subjects: *Description of the participants in the study: who, how many, key features, or characteristics.* (May not be applicable for Methods submissions)

Entering freshmen who were new to UMBC and who planned to major in STEM disciplines at UMBC were mailed personalized invitations by the Provost on his letterhead to participate in the iCubed@UMBC project. To participate in this research study, students must receive math placement exam scores that make them eligible for college algebra or higher-level mathematics courses and they may not be participants in one of UMBC's scholarship programs. Current records identify 304 students in Cohort 1, 514 students in Cohort 2, and about 450

students in Cohort 3. Figures 1 and 2 in the appendix detail how many students were assigned to the five intervention groups for Cohort 1 and 2.

Intervention / Program / Practice: *Description of the intervention, program, or practice, including details of administration and duration.* (May not be applicable for Methods submissions)

Eligible students who signed the consent forms to participate were randomly assigned into five separate groups: 1) high-status faculty mentoring with ongoing risk assessment, 2) professional staff mentoring with ongoing risk assessment, 3) placement in an active learning discussion section in pre-calculus or calculus classes in the CNMS Active Science Teaching and Learning Environment (CASTLE), 4) assistance in forming and maintaining study groups, and 5) the control group that offers a $50 UMBC Bookstore gift card. Participation takes place over the fall and spring semesters with Cohort 1 held during the 2011-2012 AY, Cohort 2 held 2012-2013 AY, and Cohort 3 held 2013-2104 AY

Faculty Mentoring - Up to ten high-status, tenured faculty mentor all students in this intervention by discipline and receive $1,000 annual stipends regardless of the number of students mentored. Project protocol with suggested meeting topics calls for the faculty mentors to hold two group meetings during the fall semester and one group meeting during the spring semester. The meetings focus on success in the discipline and the iCubed@UMBC Program Coordinator assists the faculty mentors in arranging meetings, communicating with students, and conducting the ongoing risk assessment, which has five components: 1) Scores from a first-day Quiz Zero given in key math classes to assess preparedness; 2) Responses to an Early Warning Survey send to faculty teaching STEM courses involving students in the mentoring interventions, 3) Responses to a campus-wide First Year Initiative (FYI) survey to faculty monitor student progress, 4) Student self identification, and 5) Fall Semester grades. Students identified as being at risk are invited to schedule an appointment with their faculty mentors and mentors may use an established protocol to help the students assess and address their risk factors.

Staff Mentoring – A professional staff advisor with STEM expertise mentors all students in this intervention, which follows a similar protocol and risk assessment monitoring with the student meetings focused on general success in STEM majors. One research question is whether a high-profile faculty mentor affects students differently than a staff advisor.

Active Learning – This intervention requires that participants schedule a pre-calculus or calculus discussion section in a specific campus active learning classroom (CASTLE), as is possible, and that other iCubed@UMBC participants do not schedule a pre-calculus or calculus discussion section in this location. Our analysis of student records found that one of the largest determinants of whether a student stays in a STEM major is their grade in their first math class. This treatment is designed to allow us to evaluate whether the method in which students learn mathematics affects student retention.

Study Groups – The iCubed@UMBC Program Coordinator follows a protocol to encourage and assist students in this intervention to form and/or participate in study groups. Group meetings are held at the beginning of the fall and spring semesters to introduce student-friendly information about the benefits of study groups. Follow up, including office hours around campus, throughout the semester encourages study groups and address any issues related to study groups, as requested. Each semester ends with a pizza drawing to randomly reward study group formation on students who are currently enrolled in the same class as well as their schedules.

Control Group – Students in this intervention receive no specialized services and are offered UMBC Bookstore $50 gift cards, which they sign for and present photo IDs.

All Groups - Students in all five interventions are encouraged to take advantage of the many resources and support services that are available to all students on campus. They are asked to complete two electronic surveys with the first survey sent out at the beginning of the fall semester and the second survey sent at the end of the spring semester. The time to complete the survey is about 15 to 30 minutes per survey. Students are randomly invited to participate in Cohort-based focus groups to garner student opinions about the project and intervention.

Significance / Novelty of study:
Description of what is missing in previous work and the contribution the study makes.

While many researchers recognize the value of random assignment, very few studies have implemented random assignment at the college level. The research team provide an analysis of four interventions that are known to affect student retention and graduation in STEM at UMBC using random assignment. In addition, other components of the study will: 1) analyze longitudinal data at UMBC to identify risk factors for STEM student success and 2) evaluate the cost-effectiveness of the identified interventions so as to inform the university and other universities about best practices in promoting student retention at lowest possible cost.

Statistical, Measurement, or Econometric Model:
Description of the proposed new methods or novel applications of existing methods.

The research team leader randomly assigned participants in iCubed@UMBC to five different groups (four interventions and one control group). The research team is conducting an analysis of the effectiveness of these interventions on student success and will be looking at the effects of these interventions on first-year grades, student retention at the university and in the major as well as graduation from the university. When analyzing the effects of these interventions, we will be focusing on two particular effects. The first effect is the intent to treat. This is the fact that each person in the randomly assigned group was offered the services particular to that treatment. However, not every person will take up the services. The second effect is the treatment of the treated. These are students who actively participated in the intervention. In addition to administration records on students, we are also gathering survey data. From the survey data as well as records from the individuals running our interventions, we will be able to determine who actually used the interventions.

Usefulness / Applicability of Method:
Demonstration of the usefulness of the proposed methods using hypothetical or real data.

The advantage of random assignment of students to interventions is that if assignment is truly random then it is not correlated with student characteristics. The project, therefore, no longer need to be concerned about self-selection. Individuals who are assigned to one intervention do not differ in measurable ways from students who are not assigned to the intervention. This allows for a clear analysis of the causal effects of the intervention. This was tested using observable characteristics and is presented in Table 1 and Table 2 in the appendix. The method is often difficult to implement, as individuals who are assigned to one treatment group may prefer to be in another. Another limitation of this method is that there are some concerns about providing beneficial resources to only students within a treatment.

Research Design: *Description of the research design.* (May not be applicable for Methods submissions)

The iCubed@UMBC research design is fairly straightforward given that the project uses

random assignment. The bigger issues have been 1) how best to recruit students to the study 2) how to get recruited students to participate in the interventions and complete the surveys, and 3) how to best handle different definitions of and varying competencies in active learning techniques among faculty and graduate students. The first Cohort that started in Fall 2011 has, in many ways, served the project well as a pilot activity. It has taken many steps and missteps to address these issues, especially in figuring out the best means to recruit students as well as how best to engage them in the interventions. At the suggestion of the members of our Internal and External Advisory Boards, project staff focused on building camaraderie among the students at the beginning of Cohort 2's academic year in an efficient and effective way. With the help of the Office of Student Life, a protocol was created for one-hour team meetings during UMBC's Welcome Week just before the start of classes. Team meetings were held in five large class locations at the same time with invitations from the Provost mailed to the recruited students' homes. Each intervention was given a team name and color. Free iCubed@UMBC tee shirts, in one of the five team colors, were distributed at the team meetings that included a brief overview explaining the purpose of the study and what was expected of the students. Emphasis was placed on the importance of each participant and the two surveys they would be asked to complete. Volunteers conducted activities intended to get students to interact and have fun. Volunteers filmed small group presentations by the students about iCubed@UMBC to be used in the creation of an iCubed@UMBC *YouTube* video. Guests, including the University President, the Provost, and the Faculty Mentors, made special appearances at the meetings, which ended with ice cream treats for everyone. Participation increased among Cohort 2 and the protocol for Welcome Week team meetings was repeated for Cohort 3.

Data Collection and Analysis: *Description of the methods for collecting and analyzing data.* (May not be applicable for Methods submissions)

The iCubed@UMBC project would not be possible without the collaboration and cooperation between many divisions on campus. The largest resource for the project's research team, in terms of data collection, has been the UMBC Office of Institutional Research, which provides comprehensive demographic information on all participants as well as additional information on their course-taking behavior, grades, and declared majors.

Findings / Results: *Description of the main findings with specific details.* (May not be applicable for Methods submissions)

Although the project continues to be in its data collection phase, the research team members hope to have an analysis of the effects of these interventions on first-year grades and second-year retention. The project is just beginning its third and final Cohort and the remaining time of the study will be devoted to data analysis and dissemination.

Conclusions: *Description of conclusions, recommendations, and limitations based on findings.*

The iCubed@UMBC experience, so far, has demonstrated the difficulties inherent in implementing a large-scale, random assignment study of entering freshman at a public four-year university and the necessity of involving much of the campus in supporting such an ambitious endeavor. Addressing these challenges has provided many useful lessons with broader applications to other initiatives. The planned analysis of data from over 1200 student participants in the three iCubed@UMBC cohorts promises a better understanding of key interventions that may increase student participation and success in STEM fields.