Unique Collaborations between Engineering and Engineering Technology Programs

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Abstract

Colorado Mesa University (CMU), located in Grand Junction, and University of Colorado Boulder (CU-Boulder) are partnering to deliver a mechanical engineering (ME) program in its entirety on the CMU campus. The third cohort of ME students is graduating in May 2014. The CMU/CU-Boulder ME Partnership Program enables students to earn a Bachelor of Science in ME degree and complete the entire program in residence at CMU. The first two years of classes are offered by CMU and taught by CMU faculty. Upper-level ME specific classes are offered by CU-Boulder and taught by CU-Boulder faculty on the campus of CMU. The successful student completing all requirements then earns the degree from CU-Boulder.

In collaboration with and to complement the Partnership, CMU is offering a 4-year Mechanical Engineering Technology (MET) Program. CMU is only one of a handful of universities nationwide that offer both E and ET degrees under a single umbrella. The first two years of the curriculum associated with the ME and MET programs are nearly identical, providing flexibility to students who might be unsure of their career paths. The second cohort of MET students is graduating in May 2014.

The purpose of this paper is to provide a description of the collaboration between the E and ET programs, particularly highlighting the curricula, and how a partnership such as this might be used as a template and extended into other venues.

Introduction

Colorado Mesa University (CMU), formerly known as Mesa State College, and the University of Colorado Boulder (CU-Boulder) entered into a partnership in February 2008 to deliver a mechanical engineering (ME) program in its entirety in Grand Junction, Colorado, the home of CMU. CU-Boulder is a public research university with a total enrollment of 32,500 students: 5,000 of whom are in the engineering college. It is one of the 30 'Public Ivy League Schools' in the nation. CMU is a public comprehensive university with a total enrollment of 9,500 students. There were no engineering programs on campus at CMU or in all of Western Colorado prior to 2008. CU-Boulder and CMU are separated by a distance of 250 miles - a 4-hour drive over the Continental Divide through the Rocky Mountains.

The CMU/CU-Boulder ME Partnership Program enables students to earn a Bachelor of Science in Mechanical Engineering (BSME) degree while in residence all four years on the CMU campus in Grand Junction. The first two years of classes, including seven lower-level engineering courses, are offered by CMU and taught by CMU faculty. Students pay CMU tuition for these courses and scholarships are awarded through CMU. Upper-level junior and senior ME engineering classes are offered by CU-Boulder at CMU and are taught by CU-Boulder faculty who are based in Grand Junction. Students pay CU-Boulder tuition for this part of the program. CU-Boulder reimburses CMU 25% of the tuition for all CU-Boulder courses. All financial aid and scholarships during the latter portion of the program are strictly administered through CU-

Boulder. Supplemental upper-division humanity and social science elective courses as well as technical elective courses are offered by CMU to junior and senior CU-Boulder students. Student fees are based on the total number of credits in which a student is enrolled and these fees are paid to CMU. Students completing all requirements are awarded the BSME degree by the Department of Mechanical Engineering, College of Engineering and Applied Science at CU-Boulder. The Partnership Program was autonomously accredited, i.e., independent of the home department's program in Boulder, by the Engineering Accreditation Commission (EAC) of ABET in August 2013.

It was quickly realized that the net cast to recruit highly qualified students for the Partnership Program could catch many students who were unprepared for the rigors and prescriptive nature of a CU-Boulder ME Degree. Forward thinking administrators encouraged the development of a more flexible degree program that could complement the resources allocated to the Partnership. Hence, CMU's MET Program was launched in January 2010. Few faculty and small student numbers, along with limited resources designated for a single program, forced an innovative approach in developing the curriculum for the MET Program.

It is interesting to note that CMU is one of only nine universities nationwide that offers degrees in engineering (E) and engineering technology (ET) under a single umbrella.[1] Although the two degrees are granted by separate institutions, the common umbrella is that the programs are administered under the guise of a single director.

To date, there have been two graduating classes of ME Partnership students: nine and thirteen in the spring of 2012 and 2013, respectively. The first cohort of MET students (two students) graduated in May 2013. At the beginning of the spring 2014 semester, it is expected that there will be an additional 13 ME graduates and 6 MET graduates in May 2014. The accreditation, administration, budget, curricula, enrollment, and staffing of the two programs were explained previously.[2]

Faculty makeup, small class sizes, and the innovative common curriculum during the first two years are important aspects of the collaboration's success. A summary of staffing and enrollment to provide context is provided below, along with specific details of the curricula.

Staffing

Staffing for the CMU/CU-Boulder Partnership Program comprises:

Partnership Director – The role of the Partnership Director includes oversight of the lower-division CMU portion of the program, in addition to the upper-division CU-Boulder portion of the program, with a workload formula of 50% teaching (equivalent to three CU-Boulder courses per academic year) and 50% service (which includes the administrative duties). The Partnership Director is employed by CU-Boulder, which is reimbursed by CMU for 25% of the director's salary and benefits (for his part in the administration of the lower-division portion of the program). The Partnership Director acts as the pseudo engineering department chair at CMU and oversees the MET Program.

CU-Boulder Teaching Faculty – Two full-time faculty with an 80% teaching (six courses per year) and 20% service workload are employed by CU-Boulder. Additionally, there is a half-time instructor whose duties include teaching one class per year and serving as the laboratory technician for CU-Boulder courses. Another half-time instructor was added January 2014 with 25% of his salary reimbursed by CMU (the teaching workload for this instructor is 1.5 CU-Boulder and 2 CMU courses per year).

CMU Engineering Faculty – Three full-time tenure-track CMU Assistant Professors who primarily teach the lower-division CMU engineering courses and upper-level MET courses are employed by CMU. The workload formula for the CMU faculty is 60% teaching, 20% scholarly activity, and 20% service. The teaching component is eight courses per year. CU-Boulder reimburses half of the salary of one of the three CMU faculty members.

CMU Laboratory Technician - A one-third time laboratory technician dedicated to first and second year courses as well as the MET Program is employed by CMU.

CMU/CU-Boulder Administrative Assistant – A half-time administrative assistant has responsibilities for the ME portion of the program and is employed by CMU. CU-Boulder reimburses one quarter of the salary of the administrative assistant to CMU.

Note that the monetary exchange for shared employees between the two institutions is essentially equal, with CMU reimbursing 25% of the director's and 25% of a faculty's salary to CU-Boulder and CU-Boulder reimbursing 50% a faculty and 25% the administrative assistant salaries.

Enrollment

The definitions of terms used to describe the class standing for the engineering students follow:

CU-Boulder Matriculated **Senior**-Level ME Students: Students who have successfully completed their junior-level CU-Boulder courses and will be taking 4th-year, upper-level CU-Boulder ME courses at CMU.

CU-Boulder Matriculated **Junior**-Level ME Students: Students who have been accepted into CU-Boulder and are ready to begin their 3rd-year, upper-level CU-Boulder ME courses at CMU.

CMU on Track **Sophomore**-Level Engineering Students: Students who have completed Calculus II and Physics II and are ready to begin their required CMU lower-level, 2nd-year engineering courses. CMU considers these students 'General Engineering' students. Students classified in this level may be MET students who have not declared 'MET' yet.

CMU on Track **Freshman**-Level Engineering Students: Students who are Calculus ready for fall term. CMU considers these students 'General Engineering' students. Students classified in this level may be MET students who have not declared 'MET' yet.

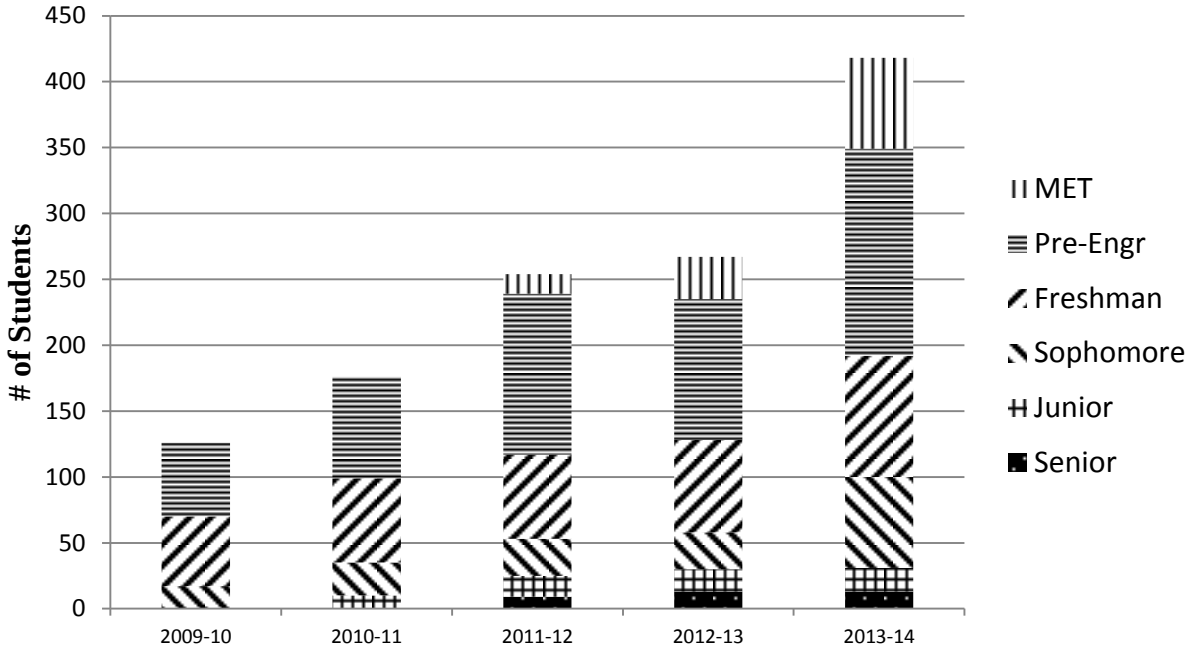
Pre-Engineering Students: Students who have expressed an interest in becoming mechanical engineering students but are not calculus ready. They may be taking the Intro to Engineering or

CAD courses. Students classified in this level may be MET students who have not declared 'MET' yet.

Mechanical Engineering Technology Students – Students who have declared their desire to be in the MET Program. The leading cohort of MET students (two students) graduated in May 2013. Due to the low numbers of MET students, they have not been delineated into junior, sophomore or freshmen levels. It is important to note that students do not have to formally declare an ME or MET major until the beginning of their junior year.

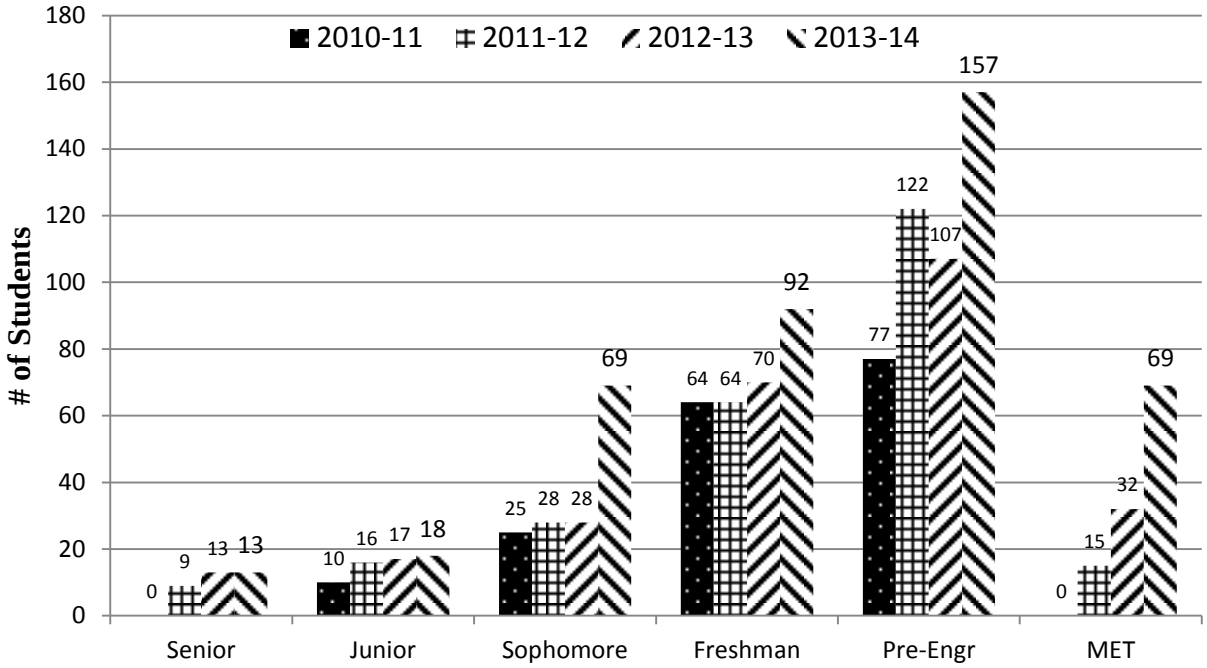
Data related to student enrollment for the first five years of the engineering programs is shown in Fig. 1. Promotional effort within the state and nationally during the first four years of the program is paying off, as indicated by the 62% increase in student enrollment seen in the 5th year, i.e., the 2013-14 academic year.

Fig. 1 Engineering Student Enrollment, Aug. 2013



The positive increase in enrollment can be seen in Fig. 2, denoted by class. A factor of two increase in the number of dedicated MET students is seen in the last two years of the program; this is attributed to a better explanation of the MET degree in the "Intro to Engineering" class which began in fall 2012. Thanks to the "Intro to Engineering" class (which is required for both programs), students are better versed in the differences in E versus ET curricula, and they benefit from hearing upper division students talk about their perceptions of the two programs, as well as listening to industry representatives speak about the job opportunities available after graduation. Keep in mind that a student does not have to actually declare the E or ET path that they want to pursue until they begin their junior year of courses.

Fig. 2 Engineering Student Enrollment as a Function of Class, Aug. 2013



Philosophy of the MET Program

The fundamental guiding principles that have shaped the establishment of the MET Program are as follows:

- Accreditation through the Engineering Technology Accreditation Commission (ETAC) of ABET will be sought for the MET program in fall 2015. Three cohorts of students will have graduated by this date.
    - An important aspect of the future of the MET Program is a pending name change. The new name is Applied Mechanical Engineering and ABET accreditation will be sought through ETAC. Program administrators believe that the name change will help combat the national perception and bias that graduates of a BSMET program are "lesser" engineers who are sometimes classified as engineering technicians in industry (a designation typically reserved for an associates degreed individual).

- The Fundamentals of Engineering (FE) Exam will be a required component of graduation for MET students. Note, to sit for the FE in Colorado, a student must be graduating from an ABET accredited program. We will have to wait until after successful accreditation in 2015 to implement this requirement.

- Differential and Integral Calculus are introduced early in the curriculum to allow ME and MET students to be co-enrolled in the first two years of either program.

- Faculty are not labeled as E or ET but are allowed to freely teach between both programs.

- Students exiting the MET Program will be on par with the ME graduates as far as

entering industry and being productive members of an engineering team.

- Students interested in graduate school, NASA, government agencies and labs will be advised to pursue the ME degree since these agencies pride themselves on their more theoretical approach to engineering design. This is not to say that an MET graduate cannot be successful in graduate school.

- Both the ME and MET degree options are meant to provide alternate pathways toward becoming an engineer in industry. The ME option, where differential equations are the underpinning of most of the upper-level engineering courses, provides a more theoretical path, while the MET option, where more flexibility and less theory make up the program, provides a more applied path.
  - The CMU MET Program fully supports the mantra recently adopted by the Engineering Technology Council:[3]

    "The degree is Engineering Technology, the career is engineering"

Curriculum

The innovation in the programs lies in the flexibility that a student has during their first two years. A student does not have to decide which path they will follow (the more theoretical ME degree or the more applied MET degree) when they arrive on campus. Instead, they have the benefit of trying out some engineering coursework before they choose which option to pursue. The most significant common elements of the curriculum during the first two years are listed in Table I.

Table I. Commonalities Between the ME and MET Program Curriculum. Course credits denoted in ( ).

Educational Component	Course Name
Math & Science Theory	Calculus I (4) Calculus II (4) Physics I (4) Physics I Lab (1) General Chemistry (4) General Chemistry Lab (1) Intro to Engineering Computing (3)
Applied Technology	Introduction to Machining (1)
Engineering	Introduction to Engineering (2) CAD, 3-D Modeling (3) 1st Year Engineering Projects (3) Statics (3) Material Science (2) Material Science Lab (1) Mechanics of Solids(3) Dynamics (3)
Humanities	6-Credits of Lower-Division Courses
Social Science	Technology and Society (3)
English	Technical Report Writing (3)

The 54 credits specified in Table I can be used for either the ME and MET degrees.

The significant differences between the programs are highlighted in Table II. Here, the more theoretical ME degree versus the more applied MET degree is emphasized.

Table II. Major Differences Between the ME and MET Program Curriculum. Course credits denoted in ( ).

Educational Component	MET	ME
Math & Science Theory**	None	Calculus III (4) Differential Eqs & Linear Algebra (4) Physics II & Lab (5) Physics III (3)
Applied Technology	Machine Shop (3) Welding (3) CNC I (3) CNC II (3)	Machine Shop (1)
English***	English I (3) English II (3) Speech (3)	none

** Additional content above Calculus I & II, Physics I and General Chemistry

*** It is assumed that entering CU-Boulder students have adequate backgrounds in English. Note that both sets of students are required to take a 400-level tech report writing course.

As a student enters their junior year, the majority of ME courses require Differential Equations & Linear Algebra as a pre-requisite, thus segregating the students. However, several courses such as Component Design, Manufacturing Processes and Senior Design Projects are open to students in both programs. That is, students from either ME or MET can sit in the same class since the student outcomes for these classes are common. Note that an ME student could take up to 6-credits of MET required upper-level engineering courses to fulfill their General Technical Electives. In all, up to 72-credits may be common to the two degree programs.

The courses that make up the ME and MET Programs are shown in Table III. Courses common to both programs are denoted with an "X" in the middle column. Note, the prefix ENGR and MCEN indicate courses offered by CMU and CU-Boulder, respectively.

Table III. MET and ME Program Curricula.

MET Program	Course Name	Cr	Com-mon	ME Program	Course Name	Cr	Notes
Mathematics							
MATH 119	Pre-Calculus	5					
MATH 135	Engr Calc I	4	X	MATH 135	Engr Calc I	4	
MATH 136	Engr Calc II	4	X	MATH 136	Engr Calc II	4	
STAT 200	Probability & Statistics	3					
CSCI 130	Intro to Engr Comp	3	X	CSCI 130	Intro to Engr Comp	3	
				MATH 253	Calculus III	4	
				MATH 236	Diff Eq & Linear Alg	4	MET can use as a TE
Total Mathematics		**19**	**11**			**19**	
General Education/Humanity & Social Science							
KINE 100	Health & Wellness	1					
KINA 1XX	Activity classes	2					
ENGL 111	English Comp	3					
ENGL 112	English Comp	3					
ENGL 425	Scientific Writing	3	X	ENGL 425	Scientific Writing	3	
SPCH 102	Speechmaking	3					
	History, Humanities, Fine Arts, Social Sci	12	X*	2 lower Div & 2 Upper Div Hum/SS		12	*only 6-credits can be common
SOCI 120	Tech & Society	3	X	SOCI 120	Tech & Society	3	
Total Gen Ed/Hum/SS		**30**	**12**			**18**	
Science							
CHEM 131	Gen Chemistry	4	X	CHEM 131	Gen Chemistry	4	
CHEM 131L	Gen Chemistry Lab	1	X	CHEM 131L	Gen Chemistry Lab	1	
PHYS 131	Fund of Mechanics	4	X	PHYS 131	Fund of Mechanics	4	
PHYS 131L	Fund of Mech Lab	1	X	PHYS 131L	Fund of Mech Lab	1	
				PHYS 132	Electromag & Optics	4	MET can use as TE
				PHYS 132L	Electro & Optics Lab	1	
				PHYS 231	Modern Physics	3	MET can use as TE
Total Science		**10**	**10**			**18**	
Applied Technology							
MAMT 115	Intro to Machine Shop	3	X	MAMT 102	Fund Machining	1	
MAMT 151	Industrial Welding	3					
MAMT 151	Numerical Controls I	3					
MAMT 155	Numerical Controls II	3					
Total Applied Technology		**12**	**1**			**1**	

Table III, cont'd. MET and ME Program Curricula.

MET Program	Course Name	Cr	Com-mon	ME Program	Course Name	Cr	Notes
Engineering							
ENGR 101	Intro to Engineering	2	X	ENGR 101	Intro to Engineering	2	
ENGR 125	CAD & Fabrication	3	X	ENGR 125	CAD & Fabrication	3	
ENGR 140	1st Year Projects	3	X	ENGR 140	1st Year Projects	3	
ENGR 224	Material Science	2	X	ENGR 224	Material Science	2	
ENGR 224L	Material Science Lab	1	X	ENGR 224L	Material Science Lab	1	
ENGR 261	Statics & Structures	3	X	ENGR 261	Statics & Structures	3	
ENGR 263	Mechanics of Solids	3	X	ENGR 263	Mechanics of Solids	3	
ENGR 312	Thermo & Heat	3		MCEN 3012	Thermodynamics	3	
ENGR 317	Circuits & Electronics	3		MCEN 3017	Elect & Circuits	3	
ENGR 321	Fluid Mechanics	3		MCEN 3021	Fluid Mechanics	3	
ENGR 325	Component Des	3	X**	MCEN 3025	Component Des	3	
ENGR 343	Dynamics	3	X	ENGR 343	Dynamics	3	
ENGR 426	Manf Proc & Sys	3	X**	MCEN 4026	Manf Proc & Sys	3	
ENGR 435	Industrial Controls	3	X**				ME can use as a TE
ENGR 436	Fluid & Elect Power	3	X**				ME can use as a TE
ENGR 445	Senior Projects II	3	X**	MCEN 4045	ME Design Projects I	3	
ENGR 485	Senior Projects II	3	X**	MCEN 4085	ME Design Projects II	4	
				MCEN 3030	Computational Meth	3	
				MCEN 3022	Heat Transfer	3	
				MCEN 3037	Exp Design & Data	2	
				MCEN 3032	Thermo 2	3	
				MCEN 4043	Systems Dynamics	3	
				MCEN 4037	Measurement Lab	2	
				MCEN 4047	ME Lab	2	
					MCEN Tech Electives	6	
	MET Tech Elect (TE)	7			Gen Tech Elects (TE)	6	Can be common
Total Engineering		**54**	**38**			**72**	
Total Program Credits MET		**125**	**72**	**Total Program Credits ME**		**128**	

**May be common. Care must be taken to assure that a student has $\geq$ 45 CU-Boulder credits to be eligible to graduate with a CU-Boulder degree.

The curriculum provided in Table III highlights the more theoretical ME degree with 8 more science credits and 18 more upper level engineering credits versus the more applied MET degree with 11 more applied technology credits. Of the 72 common credits, 54 are directly applicable to either the ME or MET degrees. The remaining 18 credits are common from the standpoint of having ME and MET students sitting in the same class but going for a different degree.

Stumbling Blocks Along the Way

- Faculty Buy-In. All faculty come in with a formal E education and have not necessarily had industry experience working with ET educated engineers. Many a faculty meeting includes discussion and debate about the virtues of allowing an alternative pathway to becoming an engineer that might complement the more traditional ME path.

- E & ET upper division students sitting in the same classroom. Some faculty members complain that there is a distinct demarcation between most of the E vs ET students when it comes to the quality of their work. Most of these complaints come from the faculty who teach Component Design and Manufacturing Processes where the pre-requisites and student outcomes do not distinguish between the E and ET student. Both courses are upper-division where students have already decided on the ME or MET degree. Due to the low numbers of MET students at this point, it is not clear whether the complaints signal the caliber of the initial cohort of MET students or a more systemic problem. We will watch this closely as it has the potential to disrupt a key collaboration. It should be noted that this same critique from faculty facilitating Senior Projects where ME and MET students are purposely put on integrated project-based teams has not occurred.

- Differences between CU-Boulder and CMU teaching faculty:

Criteria	CU-Boulder	CMU
Faculty Designation	Instructor	Tenure/Tenure-Track
Course Workload	6 courses/year	8 courses/year
Research Expectations	none	20% Scholarly Activities
Professional Development Funding	$2,000/year	$600/year
Adjunct Pay for a 3-Credit Course	$6,000	$2,550 w/PhD

Concluding Remarks

A partnership between a large R-1 university known for its engineering programs and a smaller regional university noted for its liberal arts and business programs is successfully graduating mechanical engineering students in a region of the state with no previous engineering presence. The smaller school has started a mechanical engineering technology program to provide an alternative pathway for students to gain an engineering degree.

Due to low initial student numbers and limited resources, an innovative curriculum is offered that forces the two programs to share faculty, staff, and laboratory equipment. Preliminary evidence indicates that this model can succeed and might be used as a template for other institutions nationally.

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