Engineering and Education Partnership: Preparing the Next Generation of Engineering Trained STEM Teachers

Michael A. de Miranda, Ph.D.
Department of Teaching, Learning and Culture
Texas A&M University

Thomas J. Siller, Ph.D.
Department of Civil and Environmental Engineering
Colorado State University

INTRODUCTION

This project broadens the STEM learning landscape by emphasizing integrated STEM (iSTEM) teacher preparation that includes integrated design (iDesign) across STEM subjects by not only preparing a new breed of engineering trained teachers, but redesigning the traditional STEM teacher preparation model to include cross STEM discipline teacher preparation that emphasizes content border crossings and prepares teachers to work in cross functional diversity teams in schools.

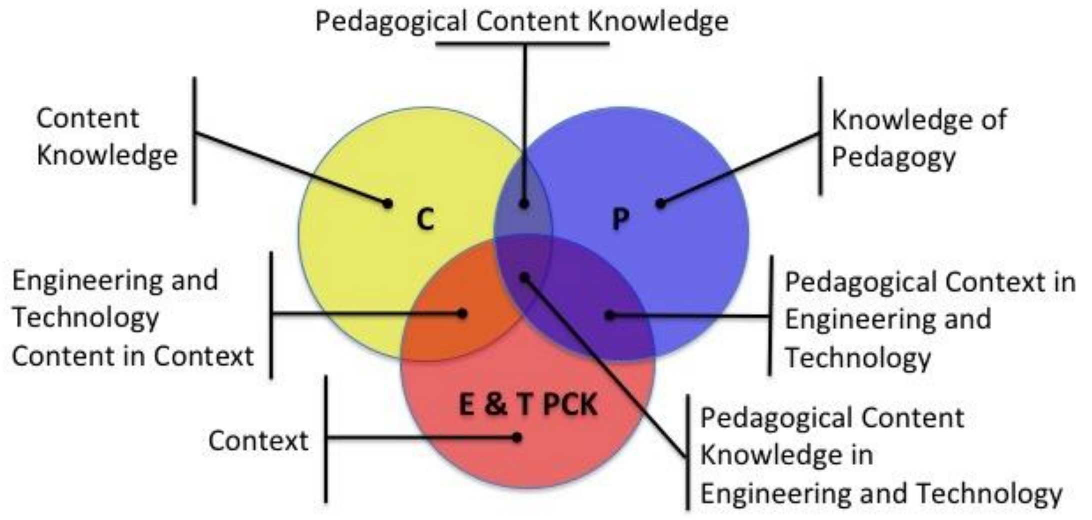
The project will result in the integration of new design projects in the engineering curricula for pre-service STEM teachers and a new cross-discipline STEM methods course that will serve as a model for other institutions to adopt.

STUDY GOALS

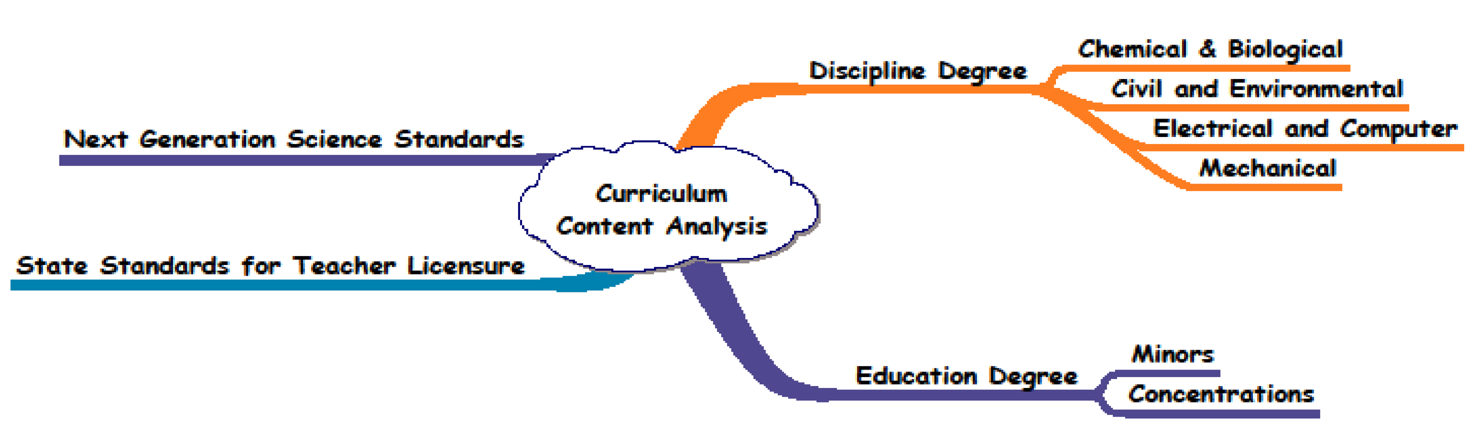
1. Identifying opportunities for counting education courses, starting with the engineering education methodology course, as part of a students' technical elective sequence in fulfillment of their engineering degree. This will be unique to each of the engineering programs.
2. Developing a framework for senior design projects that can satisfy both the needs for the engineering degree while also preparing the students for their teaching careers. This concept has been pilot tested and provides us with a starting point, but the concept has to be extended to work engineering departments.
3. Developing advising materials for students, advisers, and faculty in the departments that will work with the students in the programs.

CONCEPTUAL MODEL

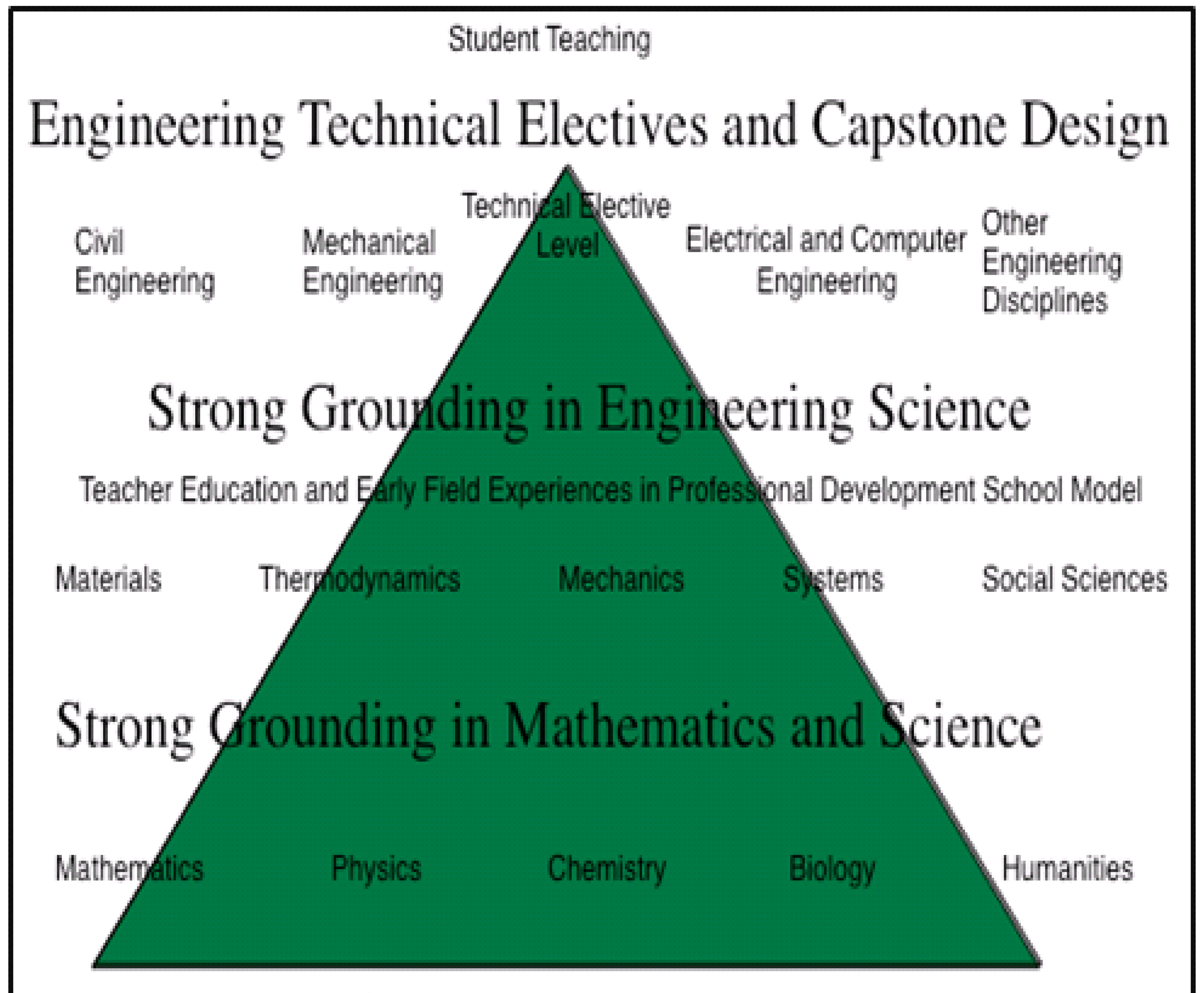
Three fundamental pillars informing the design and approach to developing pedagogical content knowledge in engineering pre-service teacher preparation; teacher contents knowledge, knowledge of pedagogy, and contextual applications in engineering.



METHODS



CURRENT MODEL



The Engineering Science and Technology Teacher Education Pyramid

Our current model partners pre-service preparation with a Specialty degree in Engineering Science or Engineering Technology. It draws from course work in the traditional engineering departments along with mathematics and science courses. Students graduate with an accredited engineering degree along with the authorization for teacher licensure.

CURRENT PROGRESS

State Licensure Requirements in Engineering or Technology Education

Colorado Content Standards	Civil & Environmental Engineering	Chemical and Biological Engineering	Electrical & Computer Engineering	Mechanical Engineering
To be endorsed in Technology Education early adolescence: ages 11-15 or young adult: ages 14-18+, an applicant shall have completed broad liberal arts preparation, the approved program of professional education as prescribed in section 5.00 of the state board of education rules, and an approved program in technology education designed to develop knowledge and skills in the following areas:				
Knowledge: the beginning technology educator shall have:				
a basic understanding of the history of technology education and the historical development and trends of technology and technology education.		CBE 101		MECH 103 (MECH 100, MECH 101) MECH 105 (MECH 102) MECH 201 MECH 301 (MECH 302; MECH 304)
an extensive preparation in technology systems and processes and demonstrate applied knowledge with respect to the following areas.				
communications/information - including verbal, written, graphic, and electronic components.	CIVE 102, CIVE 103, CIVE 305 (elective)	CBE 101 CBE 451 CBE 452	ECE 102 ECE 103 ECE 303 ECE 421	MECH 105 (MECH 102) MECH 201 MECH 301 (MECH 302; MECH 304) MECH 486A MECH 486B
transportation - including power, energy, mechanical systems, and land/sea/air/space transportation of people and materials.	CIVE 303, MECH 237?		ECE 465	MECH 307
production - including construction, manufacturing, authoring, design, and prototyping	CIVE 402 and 403	CBE 451 CBE 452	ECE 401/402	MECH 103 (MECH 100; MECH 101) MECH 105 (MECH 105) MECH 301 (MECH 302; MECH 304) MECH 307 MECH 325 MECH 486A MECH 486B MECH 262
additional preparation and demonstrate applied knowledge in the natural physical sciences, including environmental, as used in technological systems and processes.	PH 141, CHEM 111, Science Tech elective CIVE 438	CBE 101	ECE 341 ECE 342 ECE 430 ECE 442 ECE 444 ECE 457 ECE 401/402	MECH 105 (MECH 105) MECH 262, MECH 337
additional preparation and demonstrate appliedknowledge in mathematics as used in technological systems and processes.	MATH 160 MATH 161 MATH 261 MATH 340 CIVE 202 and CIVE 203 (Statistics)		ECE 103 ECE 202 ECE 303 ECE 311 ECE 312 ECE 341 ECE 342 ECE 401/402 ECE 411 ECE 412 ECE 421 ECE 423 ECE 430 ECE 442 ECE 444 ECE 457 ECE 481A2 (Robotics)	MECH 301 (MECH 302; MECH 304) MECH 307
a knowledge and understanding of workforce preparation documents and employability skills and standards.	CIVE 402, CIVE 403 (professional licensure?)	CBE 101 CBE 493	ECE 401/402	MECH 103 (MECH 100; MECH 101) MECH 301 (MECH 302; MECH 304) MECH 325
a basic understanding of the principles of high productivity organizations from business and industry.		CBE 493	ECE 401/402	MECH 486A MECH 486B
a basic understanding of the economic, political, and legal consequences inherent within the application of technological systems and processes to our society.	CIVE 402 and 403	CBE 101 CBE 493	ECE 401/402	MECH 103 (MECH 101; MECH 100) MECH 105 (MECH 102) MECH 301 (MECH 302; MECH 304) MECH 486A MECH 486B
extensive preparation in application of the various tools accessible by students to facilitate improved self-learning.		CBE 101	ECE 204	MECH 103 (MECH 101; MECH 100) MECH 105(MECH 102) MECH 307
a basic understanding of the methodologies of research into projected developments and applications of emerging technologies.	CIVE 302 (materials)	CBE 333 CBE 443	ECE 401/402	MECH 262 MECH 201 MECH 325 MECH 486A MECH 486B
an understanding of good questioning skills and techniques to be used with students and peers to collect, organize, and interpret information.		CBE 101 CBE 333 CBE 443 CBE 452	ECE 401/402	MECH 325 MECH 486A MECH 486B
the knowledge and understanding to organize and manage a student organization.	?Possibly require at least a year of participation in a student org?			

Standards for Engineering (Texas) or Technology Education licensure (Colorado) include knowledge requirements, shown in the table above, along with performance requirements (available in handout). Each engineering department was requested to review these requirements and indicate, which, if any of their required courses provided the required content. The identified course are shown above in the content matrix.

NEXT STEPS

1. Use course mappings to create programs of study for each degree program to partner with pre-service teacher preparation program
2. Develop appropriate senior design projects to satisfy both engineering and teacher licensure requirements.
3. Develop integrated STEM methods course.

CONCLUSION

1. The content mapping shown in the table indicate that engineering degrees satisfy many, but not all, State Standards requirements..
2. As with our current approach, education courses will fill in the missing content materials to complete the requirements.
3. Based on the content mapping, Engineering Technology and Mechanical Engineering provides the most comprehensive coverage of requirements while Chemical and Biological Engineering covers the least.

TEACHING, LEARNING & CULTURE
TEXAS A&M UNIVERSITY

Colorado State University
COLLEGE OF ENGINEERING

This program is based upon collaborative work supported by a National Science Foundation Grant No. 1525816; Colorado State University, Thomas J. Siller and Michael A. de Miranda, Principal Investigators. Any opinions, findings, conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.