


**T.J. SMULL**  
 COLLEGE OF ENGINEERING  
 OHIO NORTHERN UNIVERSITY



A PREMIER EDUCATION. INSPIRING CREATIVITY. SUPPORTING INNOVATION.

## Toward a New Paradigm: A Bachelor of Science Degree with a Major in Engineering Education

Ken Reid and Eric Baumgartner  
Ohio Northern University

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## Motivations: National Academies

- *Rising above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*
  - “Education in science, mathematics, and technology has become a focus of intense concern within the business and academic communities. The domestic and world economies depend more and more on science and engineering. But our primary and secondary schools do not seem able to produce enough students with the interest, motivation, knowledge, and skills they will need to compete and prosper in such a world.”


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## Motivations: National Academies

- *Standards for K-12 Engineering Education*
  - “For a country like the United States, which is dependent on technological development, we can think of few subjects as critical as engineering to building an informed, literate citizenry, ensuring our quality of life, and addressing the serious challenges facing our country and the world.”
- *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*
  - “K–12 engineering education may improve student learning and achievement in science and mathematics; increase awareness of engineering and the work of engineers; boost youth interest in pursuing engineering as a career; and increase the technological literacy of all students.”


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## Motivations: President's Council of Advisors on Science and Technology

- *Prepare and Inspire: K-12 Education in Science, Technology Engineering and Math (STEM) for America's Future*
  - "STEM education will determine whether the United States will remain a leader among nations and whether we will be able to solve immense challenges in such areas as energy, health, environmental protection, and national security."
  - "The most important factor in ensuring excellence is great STEM teachers, with both deep content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well."

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## Recommendations

- *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*
  - "The American Society for Engineering Education (ASEE), through its Division of K-12 and Pre-College Education, should begin a national dialogue on preparing K-12 engineering teachers to address the very different needs and circumstances of elementary and secondary teachers and the pros and cons of establishing a formal credentialing process."

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## Recommendations

- *Standards for K-12 Engineering Education?*
  - "The committee concluded that, **although it is theoretically possible to develop standards for K-12 engineering education, it would be extremely difficult to ensure their usefulness and effective implementation.** This conclusion is supported by the following findings: (1) there is relatively limited experience with K-12 engineering education in U.S. elementary and secondary schools, **(2) there is not at present a critical mass of teachers qualified to deliver engineering instruction,** (3) evidence regarding the impact of standards-based educational reforms on student learning in other subjects, such as mathematics and science, is inconclusive, and (4) there are significant barriers to introducing stand-alone standards for an entirely new content area in a curriculum already burdened with learning goals in more established domains of study."

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## Observations

- Engineering Education Standards
  - Not as much a matter of *if*, but *when*
  - Standards may be stand-alone or incorporated into science and/or mathematics standards
- Proliferation of Pre-Engineering Programs
  - Project Lead the Way (PLTW)
    - Over 350,000 students, nearly 4,000 schools, all 50 states
  - The Infinity Project, SMU
  - Engineering the Future and Engineering is Elementary, The Museum of Science, Boston




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## Observations

- Other Programs
  - Engineering summer camps
  - Design competitions (FIRST, NASA Moonbuggy, etc.)
  - Teacher in-service activities
- All of these efforts require educators who have deep content knowledge in engineering




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## Putting the “E” in STEM Teacher Preparation

- Colorado State University – Fort Collins
  - Started offering Engineering Education concentration in 2007 resulting in Technology Education certification
- Utah State University
  - Engineering and Technology Education major with emphases in Technology Education or Trade and Technical Education
- UTeach at University of Texas at Austin
  - Started in 1997 to encourage science and math majors to be teaching certified, but only now beginning to engage engineering students
- Ohio Northern University
  - Engineering Education major beginning in Fall 2011




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## ONU's Engineering Education Major

- Timeline
  - May 2009: idea first formulated
  - Spring 2010: major approved by college's curriculum committee and entire faculty
  - October 2010: major approved by ONU's Board of Trustees
  - October 2010: proposal submitted to Ohio Board of Regents (OBR)
  - March 2011: receipt of approval from OBR to offer major
  - First cohort begins in Fall 2011 semester




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## ONU's Engineering Education Major

- Underlying Principles
  - Completion in 4 years
    - 128 credit hours maximum to be consistent with other engineering majors at ONU
  - Meet ABET accreditation requirements as a General Engineering program
  - Students capable of sitting for Fundamentals of Engineering (FE) Exam
  - Achieve State of Ohio AYA Mathematics Teacher Certification requirements




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## ONU's Engineering Education Major

### Fall Semester – Freshman

- Engineering Orientation
- Introduction to Engineering 1
- Writing Seminar
- Calculus 1
- Communication in the Classroom
- Culture and Schooling

### Spring Semester – Freshman

- Introduction to Engineering 2
- Calculus 2
- Physics 1 and Physics 1 Lab
- Five Day Field Experience 1
- Exceptional Learners




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## ONU's Engineering Education Major

Fall Semester – Sophomore      Spring Semester – Sophomore

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|--|---|
| <ul style="list-style-type: none"> <li>• Electrical Circuits</li> <li>• Statics</li> <li>• Differential Equations</li> <li>• Five Day Field Experience 2</li> <li>• Extradisciplinary Seminar</li> </ul> | <ul style="list-style-type: none"> <li>• Dynamics</li> <li>• Strength of Materials or Engineering Material Science</li> <li>• Calculus 3</li> <li>• Foundations of Math</li> <li>• Development across the Lifespan</li> </ul> |
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## ONU's Engineering Education Major

Fall Semester – Junior      Spring Semester – Junior

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|---|---|
| <ul style="list-style-type: none"> <li>• Statistics</li> <li>• Computer Applications</li> <li>• Curriculum and Assessment</li> <li>• Foundations in Geometry</li> <li>• Technical Elective 1</li> </ul> | <ul style="list-style-type: none"> <li>• Engineering Education 1</li> <li>• Educ. Psychology &amp; Instructional Practices</li> <li>• Literacy Across Content Areas AYA/MA</li> <li>• Technical Elective 2</li> <li>• Technical Elective 3</li> </ul> |
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## ONU's Engineering Education Major

Fall Semester – Senior      Spring Semester – Senior

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| <ul style="list-style-type: none"> <li>• Engineering Education Senior Design 1</li> <li>• Engineering Education 2</li> <li>• Abstract Algebra</li> <li>• Integrated Math Methods</li> <li>• Technical Elective 4</li> </ul> | <ul style="list-style-type: none"> <li>• Engineering Education Senior Design 2</li> <li>• Leadership Seminar in Education</li> <li>• Student Teaching - Adolescent</li> </ul> |
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## ONU's Engineering Education Major

- Technical Elective Tracks
  - Robotics
  - Computers
  - Infrastructure (Civil)
  - System Design
  - General Engineering




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## ONU's Engineering Education Major

- Engineering Education 1
  - To include topics from history of engineering and math/science that apply to engineering, an overview of the mathematical foundation of engineering, graphing and the use of technology in a K-12 classroom
- Engineering Education 2
  - To include topics from pedagogy of engineering in a K-12 environment, use of pedagogical tools, curriculum development and current policy issues




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## ONU's Engineering Education Major

- Engineering Education Senior Design 1
  - Educational aspects within a team-based design project in area in or related to a specific discipline within engineering issues regarding effective teamwork. Utilization of project management standards. Establishment of project capabilities, requirements and constraints. Pedagogy and/or policy issues as applied to projects.
- Engineering Education Senior Design 2
  - Continuation of Engineering Education Senior Design 1. Demonstration of educational aspects of project capabilities. Acceptance testing. Project deliverables.




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## Status and Future Plans

- Four students enrolled in inaugural cohort
  - Late approval of major by Ohio Board of Regents did not allow for nominal student recruitment processes
- “STeM to STEM” eTech Ohio grant received
  - Teacher professional development workshop held in June 2011 for the infusion of engineering activities into the classroom
- Investigation of expanding teacher certification to physics and/or technology



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## Conclusions

- Unique program that fully integrates engineering education with math teacher certification
- Resulting teachers will have deep content knowledge in engineering and as well as an accurate perception of engineering as a profession
- One step towards a necessary, systemic change in teacher preparation to meet the challenge of embedding engineering into K-12 environments



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## Questions?



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