Integrating STEM into K-8 Teacher Preparation:
Fresno State’s Liberal Studies STEM Concentration

With the adoption of the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS), instruction in elementary classrooms is poised for dramatic change. Science content, which to date has received relatively little emphasis in the K-6 classroom, has been reorganized into three dimensions:

- Science and Engineering Practices
- Crosscutting Concepts
- Disciplinary Core Ideas

As the Venn diagram to the far right shows, there is considerable overlap between the NGSS Practices and the CCSS Practices. Students are expected to use evidence-based reasoning, critical thinking, and effective communication across all subjects.

For the first time, engineering is explicitly included in the science standards, not only as part of the practices, but also as a specific set of disciplinary core ideas focusing on design and linkages among engineering, technology, science, and society.

Learner performance expectations in the standards integrate key ideas from the three dimensions, resulting in learners acquiring and applying knowledge and thinking and reasoning scientifically. This approach necessitates learners’ engaging actively and directly in the practices of science and engineering in order to construct scientific understanding. Future teachers of grades K-8 need considerable preparation in order to teach STEM content with confidence and competence.

To meet this challenge, faculty at Fresno State designed a cross-disciplinary, 12-semester-unit (4-course) Science, Technology, Engineering, and Mathematics (STEM) Concentration in Liberal Studies.

The Liberal Studies STEM Concentration affords a transformative learning experience for future elementary teachers through deliberately designed integrative courses with these shared purposed:

- (a) increase interest in and generate excitement for teaching and learning about science, technology, engineering, and mathematics;
- (b) provide coherent and connected STEM learning opportunities;
- (c) model research-based and inquiry-oriented STEM pedagogy; and
- (d) facilitate awareness of the NGSS Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts (listed below).

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

### Courses:

**Environmental, Earth, and Life Sciences**
- Current environmental issues & sustainability
- Introduce and apply crosscutting concepts
- Small-group problem-solving exercises
- Actively apply and reflect on content
- Project-based independent research
- Develop enthusiasm and confidence

**Physics Pedagogy and Outreach**
- Service-learning outreach experience
- Content: Pressure, Constructivism
- Pedagogy: Discrepant events, Inquirying
- Linear momentum, Misconceptions
- Angular momentum, Conceptual change
- Bernoulli’s principle, Service learning

**Energy, Technology, & Society**
- Energy forms, transformations, and practical applications
- Hydroelectric
- Geothermal
- Nuclear
- Solar
- Wind
- Evaluating alternatives
- Environmental effects
- Analysis of energy use
- Constraints of physical laws
- Explicit connections to Engineering Literacy

**Engineering Literacy**
- Equity and Justice
- Ecosystem and Habitat
- Culture
- Air/Water/Space/Land Quality
- Energy
- Materials

**Course Elements**
- Humanities and Engineering
- Design Constraints
- Sustainability
- Context-Sensitive Solution
- Problem Solving
- Communications
- Critical Reasoning

**Lab Activities**
- Ancient construction
- Public perception of engineering
- Engineering resources
- Engineering drawings
- Engineering communication
- Spreadsheet calculations
- Engineering design

### Collaborative Faculty Activities
- Peer observation
- Guest lectures
- Roundtable discussions
- Reflective blogs

### Faculty Professional Development
- Background: NGSS & CCSS
- Crosscutting concepts and common themes
- Inquiry-oriented, student-centered pedagogy
- Project-based learning
- Integration of Science and Engineering Practices into content
- Development of innovative, transferable curriculum materials

### Student Engagement
- Motivate participation in STEM workshops and conferences, as well as coursework; promote membership in professional organizations
- Support success in K-8 STEM teacher pathways

### Institutional Support
- Multidisciplinary faculty collaboration
- Institutional support for scholarly activities in STEM educ.
- Professional development
- Transformational approach to student learning and faculty instruction
- Over 70 Liberal Studies students are in the program!