STEM 4033: Introduction to STEM Education

University of Arkansas College of Education and Health Professions
Department of Curriculum and Instruction

Program Affiliation: Career and Technical Education, Technology and Engineering Education concentration & Childhood Education, STEM Graduate Certificate

Course Number and Title: STEM 4033: Introduction to STEM Education

Catalog Description: This course provides an introduction to the foundations of STEM education disciplines and the strategies used to deliver integrative STEM education in the elementary and secondary school setting. The nature of STEM education disciplines, STEM pedagogy, teaching strategies, integrative STEM learning, STEM careers, and problem-centered instruction are addressed. STEM 4033 may be taken for undergraduate or graduate credit.

Prerequisites: None

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Office Hours: Tuesday and Thursday 9:00-11:00 and 1:30-3:00 or by appointment

Required Text: Larmer, J. , Mergendoller, J, & Boss, S. (2015). Setting the Standard for Project Based Learning: A Proven Approach to Rigorous Classroom Instruction. ASCD: Alexandria, VA. ISBN: 978-1-4166-2033-4

Relationship to Knowledge Base: This foundational course supports the "Specialty Studies" component of the Scholar-Practitioner model by providing the childhood education teacher education candidate with an in-depth study of project-based STEM education. The course includes an intense overview of the history, science, methods, and theories of integrated STEM education. The course will also provide and in-depth examination of curriculum that has been developed for integrated STEM education as well as the procedures for developing new curriculum for the elementary school classroom.

Goals: This course is designed to provide the candidate with an understanding of integrated STEM education as well as instructional strategies for teaching these subjects in the elementary school classroom.

Scholar-Practitioner Tenets: The following tenets are to be interwoven throughout all areas of the class and practicum. Scholar-practitioners are teachers, administrators, and counselors who value theory and research, comprehend theory and practice as being complementary and mutually reinforcing, and are committed to the enhancement of teaching, learning, and professional practice. The scholar-practitioner is one who:

1. *accesses, uses, and/or generates knowledge.
2. *plans, implements, and models best practice.
3. *understands, respects, and values diversity.
4. *is a developing professional and a life-long learner.
5. *is knowledgeable about teachers and teaching, learners and learning, schools and schooling.
6. *communicates, cooperates, and collaborates with others.
7. *makes decisions based upon professional standards and ethical criteria

Competencies: Upon successful completion of this course, candidates will demonstrate knowledge, skills and competencies in the following areas:

1. Develop (through the integration of the class readings, class discussions, personal use of technologies, and personal philosophy of education) a theoretically informed argument for embedding mathematical and scientific thinking strategies across the curricula (SP 1, 2, 5);

2. Demonstrate a basic knowledge of the national standards in the fields of science, mathematics, and technology education; as well as basic knowledge of the Common Core Standards (SP 1);
3. Demonstrate the ability to synthesize relevant information regarding the use of STEM thinking in elementary or secondary education (SP 1, 5);
4. Utilize the vocabulary, primary concepts, definitions, and models applicable to project-based STEM education (SP 1, 2, 5);
5. Demonstrate an ability to collect, evaluate, synthesize, and share real-world data relevant to curricula in elementary or secondary education (SP 1, 2, 5, 7);
6. Demonstrate an ability to solve problems, evaluate the efficacy of possible solutions, and discuss strategies and processes needed for effective problem solving (SP 1, 5, 6, 7) ;
7. Demonstrate the ability to work in collaborative design teams to meet given criteria and solve design problems (SP 1, 2, 3, 6);
8. Develop innovative and alternative teaching methods and learning activities that promote STEM education (SP 1, 2, 3, 5);
9. Apply STEM cognitive tools (i.e., scientific model, design loop, etc.) and resources toward solving human and environmental problems (SP 2, 3, 7);
10. Demonstrate an ability to use a variety of pedagogical strategies to enhance STEM thinking in elementary or secondary students (SP 2, 4);
11. Analyze attributes, strengths, and weaknesses of current STEM education programs, initiatives and policies at the local, state, and national levels (SP 4, 7); and,
12. Demonstrate knowledge of the historical background and development of the fields of science, mathematics, technology education, and engineering (SP 1, 5, 7).

Course Outline:

1. Background and history of the STEM movement
   a. What is the role of science, mathematics, technology, and engineering?
   b. What is the difference between science and technology?
   c. Why is STEM important?
      i. The demand for skills
      ii. National rankings and current trends
      iii. The elementary gap
   d. How is STEM different than traditional science and math
   e. The role of problem solving and design
   f. Barriers to STEM education
   g. Strategies for effective STEM education
   h. Problem-based learning
   i. Performance-based teaching and learning
2. The power and promise of STEM education
   a. Active learning and engagement
   b. The role of the standards
   c. Understanding by design--backwards design
   d. STEM and 5E teaching
   e. The relationship between the standards and engineering
   f. Delivering the standards through engineering and design
   g. Using standards to develop curriculum
3. Science as a way of knowing
   a. Inquiry-based teaching and learning
   b. How does science work
   c. Position of science in the modern world
   d. History and nature of science
   e. Unifying concepts
   f. Science, technology, and engineering
4. Mathematics as a way of knowing
   a. Position of mathematics in the modern world
   b. Mathematics as a way of knowing
   c. Mathematical focal points

    i. Mathematical thinking
    ii. Mathematical importance
    iii. Mathematical fit
    iv. Mathematical connections
5. Technology and engineering
    a. Foundational concepts
    b. The engineering design loop
    c. Adhering to design parameters and constraints
    d. Technological assessment
6. Integrative STEM
    a. Disciplinary, interdisciplinary, and trans-disciplinary strategies
    b. Questioning/clarifying the problem
    c. Identifying constraints/limitations
    d. Gathering research
    e. Quantifying/mental modeling
    f. Visioning and graphic representation
    g. Drawing and modeling (including software usage)
    h. Prototyping and assessment
    i. Artifact development
    j. Communicating the results of engineering/design
7. Teaching integrative STEM
    a. Teaching with the end in mind
    b. The role of design and engineering in the classroom
    c. Curricular assessment procedures, tools, and techniques
    d. Developing curriculum and activities
    e. Instructional methods for teaching STEM
    f. Collaboration strategies and resources

Graduate Certificate in STEM: This course is a part of a STEM concentration in the Childhood Education (CHED) MAT program. This course will be taken as an introduction to STEM education during the senior year of the undergraduate CHED BSE degree prior to entering the CHED MAT--Additionally, the course may be taken as a graduate course by CHED MAT candidates who complete their BSE at other institutions (additional graduate level assignments are included). The course will prepare candidates to implement STEM content and pedagogy in the elementary classroom.

Evaluation: Learning assessments (portfolio, assignments, and quizzes) are designed to prepare the student to deliver course related material in the elementary classroom. These assessments will also serve as continuing preparation to teach integrated STEM education as well as serving as a STEM advocate or resource person in the elementary school. Grades for participating students will be calculated based on completion of the following assignments and activities:

1. **Curriculum Development/Presentation and Design Challenges (800 points):** Each candidate will develop and present STEM lessons and/or design activities related to integrated STEM education throughout the course. These projects include:
    1. Design Loop Assignment (50pts.)
    2. Narrative Curriculum Design Challenge (150pts.)
    3. Technical Procedural Curriculum Design Challenge (150pts.)
    4. Construction Block Curriculum Design Challenge (100pts.)
    5. Creativity Assignment (50pts.)
    6. Quick Challenge Curriculum Design (50pts.)
    7. Electrical Circuits Curriculum Design Challenge (150pts.)
    8. Paper Engineering (50pts.)
    9. Using Scientific Evidence to Inform Design Project - Outline (50pts.)

2. **Daily Assignments (200 points):** Candidates will be required to *participate* in ongoing weekly and in-class discussions, in/out of class lab activities, design and engineering activities, and other assignments.

3. **Final Project (100 points)**

Grading Scale: A=100-93; B=92-85; C=84-78; D=77-70; F-below 69.

Academic Honesty: As a core part of its mission, the University of Arkansas provides students with the opportunity to further their educational goals through programs of study and research in an environment that promotes freedom of inquiry and academic responsibility. Accomplishing this mission is only possible when intellectual honesty and individual integrity prevail. Each University of Arkansas student/candidate is required to be familiar with and abide by the University's 'Academic Integrity Policy' which may be found at http://provost.uark.edu/ Candidates with questions about how these policies apply to a particular course or assignment should immediately contact their instructor.

Attendance Policy: This course is reserved for candidates preparing to become professional teachers. Subsequently, the ethics and responsibilities of professional teachers will be expected of all participants. Candidates must attend all classes to receive the maximum benefit and to avoid leaving their professional responsibilities in the hands of classmates. Candidates will be allowed two "sick" days regardless if excused or unexcused, if needed. Additional absences will result in the lowering of one letter grade per absence in your final grade. Furthermore, two occasions of coming late to class or leaving early will be counted as one absence. Candidates are expected to arrive early, stay focused and attentive during the class, and submit all required materials prior to the due date. Late work will not be accepted for full-credit.

Professionalism: All candidates are to complete their own work during the semester. Although candidates are allowed to share ideas and learn from one another throughout the semester, students are not allowed to copy another person's work. All assignments must be original and completed individually unless working as a team on a given assignment.

Candidates are required to maintain professional decorum during class. Cell phones and other electronic devices must be turned off and out of sight during class. Inappropriate and disruptive classroom behavior (including the use of cell phones) will result in the loss of points from daily assignment grades. The only exception to this rule is when using a device to conduct research, take photos, record times, use appropriate software, etc. during a STEM design challenge while working in design teams.

Syllabus Change: The instructor reserves the right to make changes as necessary to this syllabus. If changes are made, advance notification will be given to the class.

Research Base and Course Resources: In addition to the University library, guest speakers, and journal articles distributed by the professor, the following reference materials will be used extensively:

Hallerman, S., Larmer, J., & Mergendoller, J. R. (2011). *PBL in the elementary grades: Step-by-step guidance, tools and tips for standards-focused K-5 projects*. Novato, CA: Buck Institute for Education.

International Technology Education Association. (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: Author.

Arthur, W. B. (2009). *The nature of technology: What it is and how it evolves*. New York, NY: Free Press.

Brett, D. (2003). *Tales from the Blue Ox: A hands-on manual of traditional skills from the Blue Ox Millworks Historic Park*. Lakeville, MN: The Astragal Press.

Britton, E., De Long-Cotty, B., & Levenson, T. (2005). *Bringing technology education into K-8 classrooms: A guide to curricular resources about the designed world*. Thousand Oaks, CA: Corwin Press.

Committee on Science and Mathematics Teacher Preparation. *Educating teachers of science, mathematics, and technology: New practices for the new millennium*. Washington, DC: National Academy Press.

Francis, D. (Ed.). (1994). *Technology—a curriculum profile for Australian schools*. Carlton South Vic, Australia: Curriculum Corporation.

Gotimer, K. K. (Ed.). (1993). *Impacts of technology*. Paramus, NJ: Globe Book Company.

Hazen, R. M. & Trefil, J. (1990). *Science matters: Achieving scientific literacy*. New York, NY: Doubleday.

Hutchison, J. & Karsnitz, J. R. (1994). *Design and problem solving in technology*. Albany, NY: Delmar Publishers Inc.

Kelley, T. & Littman, J. (2001). *The Art of Innovation: Lessons in creativity from IDEO, America's leading design firm*. New York, NY: Doubleday.

Layton, D. (1993). *Technology's challenge to science education*. Bristol, PA: Open University Press.

Mastascusa, E. J., Snyder, W. J., & Hoyt, B. S. (2011). *Effective instruction for STEM disciplines: From learning theory to college teaching*. San Francisco, CA: Jossey-Bass.

Michaelsen, L. K., Baumen Light, A., & Fink, L. D. (Eds.). (2004). *Team-based learning: A transformative use of small groups in college teaching*. Sterling, VA: Stylus Publishing, LLC.

Nye, D. (2007). *Technology matters: Questions to live with*. Cambridge, MA: The MIT Press.

Pearson, G. & Young, A. T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC: National Academy Press.

Petroski, H. (1996). *Inventing by design: How engineers get from thought to thing*. Cambridge, MA: Harvard University Press.

Petroski, H. (2003). *Small things considered: Why there is no perfect design*. New York, NY: Vintage Books.

Petroski, H. (1992). *To engineer is human: The role of failure in successful design*. New York, NY: Vintage Books.

Susskind, C. (1973). *Understanding technology*. Baltimore, MD: The Johns Hopkins University Press.