STEM 40303/50303: Introduction to STEM Education

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

Program Affiliation: STEM Education; Childhood/Elementary Education; STEM Graduate Certificate

Course Number and Title: STEM 40303/50303: Introduction to STEM Education

Catalog Description: This course provides an introduction to the foundations of STEM education disciplines and the strategies used to deliver integrated STEM education in the elementary and secondary school setting. The nature of STEM education disciplines, STEM pedagogy, teaching strategies, integrated STEM learning, STEM careers, and problem/project-centered instruction are addressed.

Prerequisites: None

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Suggested Texts: International Technology and Engineering Educators Association (2020). Standards for technological and engineering literacy: The role of technology and engineering in STEM education.
https://www.iteea.org/Publications/stel.aspx

Larmer, J., Mergendoller, J, & Boss, S. (2015). Setting the Standard for Project Based Learning: A Proven Approach to Rigorous Classroom Instruction. ASCD: Alexandria, VA.
http://www.ascd.org/Publications/Books/Overview/Setting-the-Standard-for-Project-Based-Learning.aspx

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.

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 and middle school classroom.

Undergraduate Student 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;
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 Arkansas Elementary Standards;
3. Demonstrate the ability to synthesize relevant information regarding the use of STEM thinking in elementary or secondary education;
4. Utilize the vocabulary, primary concepts, definitions, and models applicable to project-based STEM education;

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

Graduate Student 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 and apply these competencies during the completion of an internship experience at a partner public school;
2. Demonstrate advanced knowledge of the national standards in the fields of science, mathematics, and technology education; as well as basic knowledge of the Arkansas Division of Elementary Standards including computer science;
3. Demonstrate the ability to synthesize relevant information regarding the use of STEM thinking in elementary or middle school during the internship teaching experience;
4. Utilize the vocabulary, primary concepts, definitions, and models applicable to project-based STEM education in class and within the internship teaching experiences;
5. Demonstrate an ability to collect, evaluate, synthesize, and share real-world data relevant to curricula in elementary or secondary education while completing an action research project during an internship teaching experience;
6. Demonstrate an ability to solve problems, evaluate the efficacy of possible solutions, and discuss strategies and processes needed for effective problem solving and demonstrate the ability to teach others these competencies;
7. Demonstrate the ability to work in collaborative design teams to meet given criteria and solve design problems and the ability to teach others these competencies;
8. Develop innovative and alternative teaching methods and learning activities that promote STEM education during the internship experiences;
9. Apply STEM cognitive tools (i.e., scientific model, design loop, etc.) and resources toward solving human and environmental problems and demonstrate the ability to teach these competences during the internship teaching experiences;
10. Demonstrate an ability to use a variety of pedagogical strategies to enhance STEM thinking in elementary or secondary students during the internship experiences;
11. Analyze attributes, strengths, and weaknesses of current STEM education programs, initiatives and policies at the local, state, and national levels as well as those at the internship teaching site; and,
12. Demonstrate advanced knowledge of the historical background and development of the fields of science, mathematics, technology education, and engineering.

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. Computer Science
     a. Computational thinking and problem solving
     b. Analyzing data and information
     c. Creating algorithms and computer programs
     d. Utilizing computers and communication systems
     e. Ethical impacts and appropriate use of technology
6. Technology and engineering
     a. Foundational concepts
     b. The engineering design loop
     c. Adhering to design parameters and constraints
     d. Technological assessment
7. Integrated STEM Education
     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
8. Teaching integrated STEM Education
     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 Education: 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 and middle-level classroom.

Graduate Student Requirement: Students completing this course (STEM 5033) as part of the Graduate Certificate in STEM Education will be required to develop a Philosophy of STEM Teaching in addition to undergraduate course requirements

Evaluation: Learning assessments (projects, assignments, etc.) 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. Please see Blackboard for point values.

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

1. **Curriculum Development/Presentation and Design Challenges:** 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 Process Assignment
     2. Quick Challenge Curriculum Design Assignment
     3. Literature-based Curriculum Design Challenge Assignment
     4. Technical Procedural Curriculum Design Challenge Assignment
     5. Construction Block Curriculum Design Challenge Assignment
     6. Electrical Circuits Curriculum Design Challenge Assignment
     7. Paper Engineering Design Challenge Assignment

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

3. **Final Project:** Each candidate will develop a final STEM project.

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.

Specific permissions will be provided to students regarding the use of generative artificial intelligence tools on certain graded activities in this course. In these instances, I will communicate explicit permission as well as expectations and any pertinent limitations for use and attribution. Without this permission, the use of generative artificial intelligence tools in any capacity while completing academic work submitted for credit, independently or collaboratively, will be considered academic dishonesty and reported to the Office of Academic Initiatives and Integrity.

All students are to complete their own work during the semester. Although students 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. All citations must be documented using the 6th edition of the APA manual (http://www.apastyle.org/, http://psychology.vanguard.edu/faculty/douglas-degelman/apa-style/)

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 are expected to attend every class** and 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 three absences from class regardless of if excused or unexcused, if needed. Additional absences will result in the lowering of one letter grade per absence in your final grade; however, this will result in the loss of participation points for any missed days. 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: Candidates are required to maintain professional decorum during class. 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, smart watches, 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 take notes, 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.