STEM 40403/50203: Creativity and Innovation in STEM Education

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

Program Affiliation: STEM Education - K-6 STEM Graduate Certificate and Childhood Education

Course Number and Title: STEM 40403/50203: Creativity and Innovation in STEM Education

Catalog Description: This course in technology and engineering education focuses on the development and introduction of technology and engineering-based activities to support science and mathematics instruction in the elementary classroom. Through hands-on, project-based learning challenges, students will develop an understanding of the design process and the integration of science, technology, engineering, and mathematics (STEM) often used to solve real-world problems. STEM 5023 may be taken for undergraduate or graduate credit.

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 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.

Prerequisites: STEM 40303/50303 Introduction to STEM Education

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Required Text:

Maslyk, J. (2020). Remaking literacy : Innovative instructional strategies for maker learning. Solution Tree Press.

Suggested Text:

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

Goals: This course is designed to provide knowledge and methods for solving technological problems and teaching engineering design. Elements of design and theory will be applied through the development of design briefs.

Technology: As with all teacher preparation coursework, students are expected to demonstrate technological competence in this course. This technological competence will be demonstrated through the use of the appropriate technological hardware and software as well as other web-based applications. Candidates will utilize technology that enhances the instructional process during the completion of this course.

Undergraduate Student Learning Objectives: Upon the completion of this course, students will be able to:

1. Understand the historical background and development of the fields of design and engineering;
2. Describe the goals, objectives and organization of the Standards for Technological Literacy (National Standards);
3. Apply technical tools and resources toward solving human and environmental problems;
4. Develop confidence in the use and development of design models and engineering constraints;
5. Develop the ability to work in collaborative design teams to meet given criteria and solve engineering-related problems;
6. Utilize the fundamentals of design and engineering in the development and delivery of curriculum;
7. Utilize the vocabulary, primary concepts, definitions, and models applicable to engineering and design;
8. Demonstrate the ability to communicate engineering and design concepts with colleagues and students using oral, written, artifact-based, and graphic channels of communication;
9. Develop innovative and alternative teaching methods and learning activities that promote the teaching of engineering, design and the national standards for technology; and,
10. Develop and deliver lessons related to the content of this course while paying special attention to standards, behavioral or performance objectives, lesson content, teaching strategies, lesson activities, and assessment strategies.

Graduate Student Learning Objectives: Upon the completion of this course, students will be able to:

1. Understand the historical background and development of the fields of design and engineering; and how this subject matter can be applied in the elementary and middle-level classroom;
2. Describe the goals, objectives and organization of the Standards for Technological Literacy (National Standards) and demonstrate how these standards can be applied in the elementary and middle school classroom
3. Apply technical tools and resources toward solving human and environmental problems and demonstrate the ability to teach these technical skills in the elementary and middle-level classroom;
4. Develop confidence in the use and development of design models and engineering constraints as well as the ability to craft learning experiences using these cognitive tools;
5. Develop the ability to work in collaborative design teams to meet given criteria and solve engineering-related problems, as well as the ability to prepare students to learn effectively in collaborative design teams;
6. Utilize the fundamentals of design and engineering in the development and delivery of curricula in the elementary or middle school classroom during the internship experience;
7. Utilize the vocabulary, primary concepts, definitions, and models applicable to engineering and design as well as the ability to teach these concepts to others;
8. Demonstrate the ability to communicate engineering and design concepts with colleagues and students using oral, written, artifact-based, and graphic channels of communication in class and within classrooms during the internship experience;
9. Develop innovative and alternative teaching methods and learning activities that promote the teaching of engineering, design and the national standards for technology at various internship sites; and,
10. Develop and deliver lessons related to the content of this course while paying special attention to standards, behavioral or performance objectives, lesson content, teaching strategies, lesson activities, and assessment strategies.

Content Outline

1. Introduction to engineering and design
    a. The history of design
    b. The history of the engineering profession
    c. The vocabulary of engineering and design
    d. Engineering & design as a tool for teaching technology
    e. The relationship between adjoining disciplines (science, technology, engineering and mathematics)
2. The Standards for Technological and Engineering Literacy
    a. The role of the standards
    b. The relationship between the standards and engineering
    c. Delivering the standards through engineering and design
    d. Using standards to develop curriculum
3. Solving human and environmental problems
    a. A search for a more comfortable life
    b. Technology problem solving
    c. Unexpected results/unintended consequences
4. Fundamentals of engineering and design
    a. Foundational concepts
    b. Form, function, balance, texture, etc.
    c. Adhering to design parameters and constraints
    d. Technological assessment
5. Tools of engineering and design
    a. Questioning/clarifying the problem
    b. Identifying constraints/limitations
    c. Gathering research
    d. Quantifying/mental modeling
    e. Visioning and graphic representation
    f. Drawing and modeling (including software usage)
    g. Prototyping and assessment
    h. Artifact development
    i. Communicating the results of engineering/design
6. Fundamental techniques
    a. Engineering design (innovation)
    b. Experimentation
    c. Research and development
    d. Troubleshooting
    e. Invention
7. Teaching with engineering and design

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 engineering and design
f. Collaboration strategies

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Graduate Student Requirement: Students completing this course (STEM 5023) as part of the Graduate Certificate in STEM Education will be required to develop a STEM Teaching Portfolio in addition to undergraduate course requirements

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

Evaluation: Learning assessments (design challenges, curriculum development, assignments, quizzes, 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:

1. **Daily and weekly assignments**
   Candidates will participate in ongoing daily and in-class design and engineering activities, assignments, readings, and discussions.
2. **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. Additionally, candidates will work in engineering design teams to use tools, techniques, and materials to design within established constraints. Candidates will rotate from design team to design team as they work to solve technical problems/challenges. Potential challenges this semester include:
   1. Catapult/Tools/Materials/Processes/Measurement
   2. Paper Engineering/MakeDo/CorelDRAW/C02 Laser Project
   3. 3D Printing/TinkerCAD/Cura
   4. Frugal Teacher STEAM Design Challenge
   5. Engineering a Play Design Challenge
   6. MagLev Design Challenge
   7. MakeyMakey Design Challenge
   8. Robotics, Drones, and Programming Design Challenges
   9. Maker Tech Challenge
3. **STEM Events**
   Each candidate will participate in local STEM Night events and Maker experiences in the community.
4. **Final Project – Remaking Project and Presentation**

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 two "sick" days regardless if excused or unexcused, if needed. This will result in the loss of participation points for the two missed days. 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: 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.

Textbooks and/or Supplementary Materials:

Whiting, G. & Hickey, M. (2009) *Children's engineering: A handbook for elementary educators*. Richmond, VA: Children's Engineering Educators LLC.

Whiting, G. & Hickey, M. (2010) *Beyond the basics: Highlighting the T & E in STEM education*. Richmond, VA: Children's Engineering Educators LLC.

Research Base:

International Technology and Engineering Educators Association. (2020). *Standards for technological and engineering literacy: The role of technology and engineering in STEM education*. Reston, Virginia.

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.

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.