PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION, OR REVISION OF A GRADUATE COURSE
(59000-69000 LEVEL)

DEPARTMENT: School of Engineering Education
EFFECTIVE SESSION: Spring 2013 - 2014

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

1. New course with supporting documents (complete proposal form)
2. Add existing course offered at another campus
3. Expiration of a course
4. Change in course number
5. Change in course title
6. Change in course credit/price
7. Change in course attributes
8. Change in instructional hours
9. Change in course description
10. Change in course requisites
11. Change in semesters offered
12. Transfer from one department to another

PROPOSED:
Subject Abbreviation: ENE
Course Number: 63000
Long Title: Cognitive Devices in Science, Technology, Engineering and Mathematics Learning Environments
Short Title: Cognitive Devices for STEM

EXISTING:
Subject Abbreviation
Course Number
Long Title
Short Title

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only
2. Satisfactory/Unsatisfactory Only
3. Repealable
4. Credit by Examination
5. Special Fees
6. Registration Approval Type
7. Variable Title
8. Honors
9. Full Time Privilege
10. Off-Campus Experience

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit: Range: Minimum Cr. Hrs. (Check One) To Or
   Maximum Cr. Hrs.
3. Equivalent Credit: Yes
4. Thesis Credit: Yes

Schedule Type
Lecture
Recitation
Presentation
Lab Prep
Studio
Distance
Clinic
Experiential
Research
Ind. Study
Pract/Observ

Course Description (Include Requisites/Restrictions):
This course explores the nature of technologies we use in thinking, learning and teaching. Specific focus is on cognitive tools associated with engineering activities and how to blend these tools with science and mathematical knowledge. These will range from representational tools, computational tools and cognitive tools for supporting individual and group thinking and learning. Participants in this course will be able to evaluate various learning technologies relative to specific learning goals and outcomes and will design a technological tool to support thinking, learning and/or teaching about concepts in science, engineering, mathematics and technology. Participants will also be able to identify assessment methods that indicate cognitive change in learners as a measure of the effectiveness of a device/tool in context of an activity. Professor Brophy.

Former Department Head
Date
Calumet School Dean
Date
Calumet Undergraduate Curriculum Committee
Date
Calumet Chancellor
Date

Undergraduate Curriculum Committee Date
APPROVED 1/18/13
Date Approved by Graduate Council

Office of the Registrar
Supporting Document for a New Graduate Course

To: Purdue University Graduate Council
From: Faculty Member: Sean Brophy  
Department: Engineering Education  
Campus: West Lafayette

Date: 
Subject: Proposal for New Graduate Course-Documentation Required by the Graduate Council to Accompany Registrar's Form 40G

For Reviewer's comments only  
(Select One)

Reviewer:

Comments:

Contact for information if questions arise:  
Name: Cindey Hays
Phone Number: 494-3884
E-mail: isenberg@purdue.edu
Campus Address: ARMS, Room 1321

Course Subject Abbreviation and Number: ENE 63000
Course Title: Cognitive Devices in Science, Technology, Engineering & Mathematics Learning...

A. Justification for the Course:

- Provide a complete and detailed explanation of the need for the course (e.g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

- Justify the level of the proposed graduate course (50000- or 60000-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

B. Learning Outcomes and Method of Evaluation or Assessment:

- Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.).

- Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.)

- Grading criteria (select from dropdown box); include a statement describing the criteria that will be used to assess students and how the final grade will be determined.

Criteria Papers and Projects
• Identify the method(s) of instruction (select from dropdown box) and describe how the methods promote the likely success of the desired student learning outcomes.

  **Method of Instruction** 
  [Lecture]

C. **Prerequisite(s):**

• List prerequisite courses by subject abbreviation, number, and title.

• List other prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence.

D. **Course Instructor(s):**

• Provide the name, rank, and department/program affiliation of the instructor(s).

• Is the instructor currently a member of the Graduate Faculty?  ✗ Yes  — No
  (If the answer is no, indicate when it is expected that a request will be submitted.)

E. **Course Outline:**

• Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory or field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course.

F. **Reading List (including course text):**

• A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

• A secondary reading list or bibliography should include material students may use as background information.

G. **Library Resources**

• Describe the library resources that are currently available or the resources needed to support this proposed course.

H. **Example of a Course Syllabus**  (While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the Graduate School’s Policies and Procedures Manual for Administering Graduate Student Programs. See Appendix K.)


(Revised and Approved by the Graduate Council 10/10)
A. Justification for the Course:

Provide a complete and detailed explanation of the need for the course (e.g., in the preparation of students, in providing new knowledge/training in one or more topics, in meeting degree requirements, etc.), how the course contributes to existing majors and/or concentrations, and how the course relates to other graduate courses offered by the department, other departments, or interdisciplinary programs.

This course provides students an opportunity to identify and research difficult cognitive processes associated with performing tasks in science, technology, engineering and mathematics (STEM). This is fundamental to all students interested in researching how people learn and the design of learning environments that support the transfer of knowledge from educational situation to professional practice in a STEM field. Students in this course will learn how to systematically evaluate the cognitive skills associated with performing STEM related activities, conduct literature reviews on theories that explain the challenges of acquiring these skills and develop theories for how to support the acquisition and/or amplification of these skills. In this course students learn through the context of developing a conceptual design of a cognitive device. The primary outcome is to increase their ability to evaluate complex cognitive tasks and recognize indicators that learners achieve the ability to perform this task. Also, students in this course will develop research abilities to assess learning from a cognitive perspective. This skill should transfer to situations when the students will be teaching others. In these situations students will be able to quickly diagnose a learners needs and adapt their instruction to support the learner. Students will also learn how to critically evaluate the potential of existing learning devices to achieve various levels of cognitive processing (from factual recall to innovative design thinking). A secondary outcome would be for students to construct a device they could use for themselves, with their future students, and/or to be used by instructors in a STEM discipline. Therefore, the course should increase learners potential for being an effective teacher, understand important issues of designing effective instruction and potentially develop instructional devices they can use in their course/research and share with others.

Justify the level of the proposed graduate course (50000- or 60000-level) including statements on, but not limited to: (1) the target audience, including the anticipated number of undergraduate and graduate students who will enroll in the course; and (2) the rigor of the course.

The course is designed for graduate students interested in learning the theories of how people learn concepts in technical disciplines of science, technology, engineering and mathematics (STEM). The focus of the course is on preparing students to critically evaluate learning and teaching from a cognitive perspective and learning to apply theories for the literature to support their design of a cognitive device. The course requires sufficient background and experience in a technical field that will allow students to think deeply about the knowledge needed to accomplish various cognitive tasks. Therefore, the course is tailored to graduate students with at least a master's degree in a technical field.

Prior offerings of the class have served students from the School of Engineering Education, College of Technology and the Education. Students are expected to keep up with a significant amount of reading, actively lead and participate in class discussion and design and research a cognitive device as a term project. Students are expected to generate a significant term report on their project which requires a careful synthesis of existing literature and well articulated theory on how to support learning in a specified learning environment.
B. Learning Outcomes and Method of Evaluation or Assessment:

Describe the course objectives and student learning outcomes that address the objectives (i.e., knowledge, communication, critical thinking, ethical research, etc.).

Participants in this course will be able to evaluate various learning technologies relative to specific learning goals and outcomes and will design a technological tool to support thinking, learning and/or teaching about concepts in science, engineering, mathematics and technology. Participants will also be able to identify assessment methods that indicate cognitive change in learners as a measure of the effectiveness of a device/tool in context of an activity. Participants will propose a research study to explore the hypothesis of a cognitive device they will design as part of a course, and/or a study an existing cognitive device to investigate a new research question.

The course is organized around answering several guiding questions including, but not limited to –

- What is the relationship between science, technology, education and mathematics?
- What are the fundamental cognitive skills associated with performing various tasks associated with STEM disciplines?
- How can cognition be supported and what is the direct and indirect affects?
- What is the “role” of technology in an environment?
  - What do we mean by environment?
  - What do we mean by learning environments?
- What are the limits of the device?
- What are the pros and cons of devices used to support cognition?

Describe the methods of evaluation or assessment of student learning outcomes. (Include evidence for both direct and indirect methods.)

Students are evaluated on their performance of three major components of the course, class participation, leading a class discussion, and writing a term project. Students are evaluated on their ability to process and synthesis the major points in the course readings and adequately share these insights as part of class discussions. The ability to lead a class discussion extends this skill to include helping the class make connections between various big ideas in the readings with the major topics for the course. These readings and class discussions are designed to support their ability to critically evaluate the literature and apply these ideas to their term project. The term project requires students to conduct a cognitive analysis of critical technical skills and review the literatures to help define the challenges with acquiring and using these skills. Students are assessed on their ability to sufficiently explore the literature and construct a cohesive synthesis of this literature to support their rationale for the design/evaluation of their cognitive device.

Grading criteria (select from dropdown box); include a statement describing the criteria that will be used to assess students and how the final grade will be determined.

Criteria: Papers and Projects

Identify the method(s) of instruction (select from dropdown box) and describe how the methods promote the likely success of the desired student learning outcomes.

Method of Instruction: Lecture
The Lecture method is combined with classroom discussion and students reflections on the readings. Typically, the instruction sequence begins with students reviewing a scenario related to the specific topic for the week and asked to evaluate the scenario relative to the perspectives presented in the research papers they read for that week’s session. Class session begins with discussion about main ideas in the paper and the class works together to form a model of what is presented in the papers. Lecture is used as a final synthesis of the big ideas and how the instructor sees refinements to what the students generate as a model of the topic.

C. Prerequisite(s):

List prerequisite courses by subject abbreviation, number, and title.

List other prerequisites and/or experiences/background required. If no prerequisites are indicated, provide an explanation for their absence.

Students are expected to have at least a BS in a STEM related discipline.

D. Course Instructor(s):

Provide the name, rank, and department/program affiliation of the instructor(s).

Sean Brophy, Assistant Professor, School of Engineering Education

Is the instructor currently a member of the Graduate Faculty? ☒ Yes ☐ No

(If the answer is no, indicate when it is expected that a request will be submitted.)

E. Course Outline

Provide an outline of topics to be covered and indicate the relative amount of time or emphasis devoted to each topic. If laboratory or field experiences are used to supplement a lecture course, explain the value of the experience(s) to enhance the quality of the course and student learning. For special topics courses, include a sample outline of a course that would be offered under the proposed course.

<table>
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<tr>
<th>Week</th>
<th>Major Topic</th>
<th>Tentative Readings</th>
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<td>15</td>
<td>Pros and Cons of Cognitive Devices</td>
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<td>16</td>
<td>Student Presentations</td>
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<td></td>
<td>Finals weeks</td>
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F. Reading List (including course text):

A primary reading list or bibliography should be limited to material the students will be required to read in order to successfully complete the course. It should not be a compilation of general reference material.

A secondary reading list or bibliography should include material students may use as background information.

See the course outline above. The first two readings for each week are primary and any additional readings are suggested reading for the students.

G. Library Resources

Describe the library resources that are currently available or the resources needed to support this proposed course.

The majority of references can all be accessed through the library’s databases of electronic documents.

H. Example of a Course Syllabus (While not a necessary component of this supporting document, an example of a course syllabus is available, for information, by clicking on the link below, which goes to the Graduate School’s Policies and Procedures Manual for Administering Graduate Student Programs. See Appendix K.)


ENE 69500 Section 006
Cognitive Devices in Science, Technology, Engineering and Mathematics Learning Environments

Course Credit Hours: 3

INSTRUCTOR and TEACHING FELLOW:

Sean P. Brophy, Engineering Education
ARMS 1217, 496-3316, sbrophy@purdue.edu

Science, Technology, Engineering and Mathematics disciplines require comprehension of complex interactions of a system. Experts in these disciplines continually invent new devices for managing this complexity which they use to support their inquiring into new discoveries and innovations. These tools are underutilized in our educational learning environments, and more can be done to systematically integrate them into our PreK – 16 educational processes. We invite scholars from all disciplines to investigate the multiple perspectives of the design of effective devices for thinking and learning in STEM learning environments.

COURSE DESCRIPTION

Cognitive devices provide the ability to extend and amplify our abilities to accomplish physical and intellectual activities. In some cases these devices help us develop abilities we can perform later without the use of the device. Other tools become integral parts of our process of thinking and doing. This course explores the nature of technologies we use to assist in our thinking, learning and teaching. We will specifically focus on cognitive tools associated with engineering activities and how to blend them with science and mathematical contexts. These will
range from representational tools, computational tools and cognitive tools for supporting individual and group thinking and learning.

OBJECTIVES
The participants in this course will be able to evaluate various learning technologies relative to specific learning goals and outcomes and will design a technological tool to support thinking, learning and/or teaching about concepts in science, engineering, mathematics and technology. Participants will also be able to identify assessment methods that indicate cognitive change in learners as a measure of the effectiveness of a device/tool in context of an activity. Participants will propose a research study to explore the hypothesis of a cognitive device they will design as part of a course. And/or a study an existing cognitive device to investigate a new research question.

REQUIREMENTS
The following summarize the major requirements for the course. Details for the assignments will be provided as handouts later in the semester.

CLASS PARTICIPATION (15%)
Keeping up with selected readings. Students will be expected to read extensively from a collection of readings relevant to the topics in the course.

Engage in dialogue and discussion - Students are expected to come to class prepared to discuss the assigned readings relative to the general questions stated above. In addition, students will participate in a number of small group activities designed to explore subtle issues related to the specific topics being studied.

Contribute examples to a class database of examples of cognitive artifacts (devices). Research popular news and literature for examples of cognitive devices and tools and bring examples for class discussion.

Thought papers – Each week students will be expected to write a short (one page maximum) thought paper about the specific readings and about their examples of cognitive devices and tools. The paper will be posted on Blackboard by noon on the Tuesday before our Wednesday class session. The student leading that week’s discussion may use these “thought papers” as artifacts for a learning activity conducted during class.

Provide weekly progress reports on status of term project.

Lead Class Discussion (15%)
Lead classroom discussion on designated topic- Each week a student (or pair of students) will be responsible for leading a class session around a set of readings or around an example of a “cognitive device/tool”. The students can use a range of instructional methods necessary to increase their peer’s comprehension of the big ideas related to the topic and the relevance of the article to how engineers learn.

TERM PROJECT (70%)
Design and potentially develop a cognitive device to support a STEM related cognitive activity. Each learner in this class will construct at least a conceptual design of a cognitive device to a cognitive activity they have observed in their domain area. The device can target any of the categories we will discuss in class and for any age learner. The term project is divided up into three milestones. The first is a short description of your project idea in a two slide powerpoint presentation to the class (week 3). The second milestone is a formal proposal (5 page maximum) describing the rational for the cognitive device, how it works, the cognitive processes it is intended to support and an outline of the development plan (week 7). Students will share their proposal during a 5 minute presentation of their proposal to the class. A final report will describe the current literature related to research conducted on this area, a justification for how and why this device will support cognition. The final project will include either a functional
prototype of the tool, or a detailed development plan for how to construct the tool. The last week of class will consist of 15 minute presentation of the final project.

Make a formal presentation of their work - Students will share the results of their Conceptual design as part of the last week of the course.

**MAJOR DRIVING QUESTION**
What is the relationship between science, technology, education and mathematics?
How can cognition be supported and what is the direct and indirect affects?
What is the “role” of technology in an environment?
What do we mean by environment?
What do we mean by learning environments?
What are the limits?
What are the pros and cons?

**MAJOR COURSE ACTIVITIES**
Identify, Categorizing and Evaluate Cognitive Devices
Identifying methods for Assessing Cognitive Tasks
Evaluate the pros and cons of cognitive devices/tools
Identify and explore technology tools at Purdue
Devices for data perceptualization (e.g. virtual reality and haptic devices)
Simulation tools (e.g. nanoHub.org)
Robotics
Experimental Systems (e.g. Fluid Dynamics)
Manipulative
Modeling tools

**Major Topics of Exploration**
Support of Engineering Expertise
Learning with Cognitive Devices
Individual and Social Interaction
The role of Play – learning with games and other informal situations
Teachable Agents
Representations
Visualization
Simulations
Models
Multimedia
To: The Faculty of the College of Engineering

From: Faculty of the School of Engineering Education

Subject: New Graduate Course, ENE 63000: Cognitive Devices in Science, Technology, Engineering and Mathematics Learning Environments

The faculty of the School of Engineering Education has approved the new course listed below. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ENE 63000: Cognitive Devices in Science, Technology, Engineering and Mathematics Learning Environments

Sem. 2, Lecture 3, Cr. 3.

Prerequisite: There are no course prerequisites.

Course description:

Cognitive devices provide the ability to extend and amplify human abilities to accomplish physical and intellectual activities. In some cases these devices help us develop abilities they can perform later without the use of the device. Other tools become integral parts of their process of thinking and doing. This course explores the nature of technologies used to assist in thinking, learning and teaching. In this course learners will specifically focus on cognitive tools associated with engineering activities and how to blend them with science, mathematical and technology contexts. These will range from representational tools, computational tools and cognitive tools for supporting individual and group thinking, learning and knowledge building.

The course requires sufficient background and experience in a technical field that will allow students to think deeply about the knowledge needed to accomplish various cognitive tasks. Therefore, the course is tailored to graduate students with at least a master’s degree in a technical field.

Reasons:

This course provides students an opportunity to identify and research difficult cognitive processes associated with performing tasks in science, technology, engineering and mathematics (STEM). This is fundamental to all students interested in researching how people learn and the design of learning environments that transfer knowledge learned in educational settings to professional practice in a STEM field. Also, students in this course will develop research abilities to assess learning from a cognitive perspective and
learn how to critically evaluate the potential of existing learning devices to achieve various levels of cognitive processing (from factual recall to innovative design thinking).

This course was first offered as ENE 695F Cognitive Devices for Science, Technology, Engineering and Mathematics Learning Environments (Fall 2006, Spring 2009) and ENE 69500-006 (Spring 2010-11) with an average enrollment of nine (9) students per offering. Since its first offering, 27 students have enrolled in the course. Prior offerings of the class have served students from the School of Engineering Education, College of Technology and School of Education. Evaluation results indicate the course is achieving its intended learning outcomes.

David Radcliffe, Kamyar Haghighi Head School of Engineering Education

Approved for the Faculty of the Schools of Engineering by the Engineering Curriculum Committee

ECC Minutes
Date 5-25-2012
Chairman ECC R. Copra
ENe 63000: Cognitive Devices in Science, Technology, Engineering and Mathematics
Learning Environments

Course instructor(s): Sean Brophy

Course description: Cognitive devices provide the ability to extend and amplify our abilities to accomplish physical and intellectual activities. In some cases these devices help us develop abilities we can perform later without the use of the device. Other tools become integral parts of our process of thinking and doing. This course explores the nature of technologies we use to assist in our thinking, learning and teaching. We will specifically focus on cognitive tools associated with performing tasks in science, technology, engineering, and mathematical contexts. These will range from representational tools, computational tools and cognitive tools for supporting individual and group thinking and learning.

Course learning outcomes: The participants in this course will be able to evaluate various learning technologies relative to specific learning goals and outcomes and will design a technological tool to support thinking, learning and/or teaching about concepts in science, engineering, mathematics and technology. Participants will also be able to identify assessment methods that indicate cognitive change in learners as a measure of the effectiveness of a device/tool in context of an activity. Participants will propose a research study to explore the hypothesis of a cognitive device they will design as part of a course, and/or a study, an existing cognitive device to investigate a new research question.

Course outline and Reading List

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<th>Week</th>
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<th>Tentative Readings</th>
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<tr>
<td>3</td>
<td>Mindtools, Model of Conceptual Understanding for learning</td>
<td>Discussion on the range of mindtools, exploring examples and defining possibilities for STEM related mind tools.</td>
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<td>4</td>
<td>Mindtools (continued)</td>
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### Tentative Readings

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<td>16</td>
<td>Finals weeks</td>
<td>Final paper due</td>
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#### Optional topic

|------------------------------------------|----------------------------------------------------------------------------------------------------------|

#### Text and/or Reading List

All readings are identified in the table above.

#### Grading

Students are expected to complete a number of course requirements to learn the material and demonstrate they have achieved the ability to transform the ideas presented in class into a conceptual design of a device. The major activities and percent of grade include: Final Paper 70%, Weekly Assignments and Leading class discussion(s) 15%, and Participation 15%.