Print Form

Office of the Registrar
FORM 40G REV. 10/10

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF A GRADUATE COURSE
(50000-60000 LEVEL)

EFD 54-11

DEPARTMENT School of Engineering Education

EFFECTIVE SESSION Spring ~~2012~~ ~~2013~~ 2014

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

- [X] 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/type
- [ ] 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

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

EXISTING:

Subject Abbreviation

Course Number

TERMS OFFERED
Check All That Apply:
[ ] Fall [X] Spring [ ] Summer

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] Cont Ed [ ] Ft. Wayne [ ] Indianapolis [ ] N. Central [ ] Tech Statewide [X] W. Lafayette

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 [ ] No [X]
4. Thesis Credit: Yes [ ] No [X]

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

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	~~170~~ 150	1	16	
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

2013 JAN 23 AM 10:06
RECEIVED
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COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):

This course explores the nature of technologies we use to assist in thinking, learning and teaching. Specifical 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.

Calumet Department Head Date	Calumet School Dean Date	Calumet Undergrad Curriculum Committee Date
Fort Wayne Department Head Date	Fort Wayne School Dean Date	Fort Wayne Chancellor Date
Indianapolis Department Head Date	Indianapolis School Dean Date	Undergrad Curriculum Committee Date
North Central Department Head Date	North Central School Dean Date	APPROVED 1/18/13 Date Approved by Graduate Council
West Lafayette Department Head Date 4-13-11	West Lafayette College/School Dean Date 5/29/12	Graduate Council Secretary Date 1/21/13
Graduate Area Committee Convener Date 1/18/13	Graduate Dean Date	West Lafayette Registrar Date 5/3/13

OFFICE OF THE REGISTRAR

LD 4/30/13

ENE 63000

Supporting Document for a New Graduate Course

For Reviewer's comments only (Select One)	
Reviewer:	
Comments:	

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

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 Learnin...

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? X 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.)

http://www.gradschool.purdue.edu/downloads/Graduate_School_Policies_and_Procedures_Manual.pdf

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 literatures 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.

Week	Major Topic	Tentative Readings
1	Introduction - Cognition, Devices and STEM Thinking	Pea, R.D. (1985). Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychologist*,20: 167–182. Salomon, G., Perkins, D.N. & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher* 20: 10–16.
2	Mindtools, Model of Conceptual Understanding for learning	Jonassen, D.H. (2000) Computers as Mindtools for Schools: engaging critical thinking, 2nd Edn. Upper Saddle River: Prentice Hall. Linn, M. 2003. Technology and science education: starting points, research programs, and trends. *International Journal of Science Education* 25 (6):727 - 758.

Week	Major Topic	Tentative Readings
		Jonassen, D.H. (1996) Computers in the Classroom: mindtools for critical thinking. Columbus: Merrill/Prentice Hall.
3	Visualization Data	Thomas, JJ Cook Kristin (2005). Visual Representations (Chapter 3). In Thomas and Cook (Eds) Illuminating the Path. National Visualization and Analystics Center. IEEE. http://nvac.pnl.gov/docs/RD_Agenda_VisualAnalytics.pdf Roth, W.-M. & McGinn, M.K. (1997). Graphing: Cognitive ability or practice? *Science Education* 81(1): 91–106. Tversky, Barbara (2004). Visuospatial Reasoning. The Cambridge Handbook of Thinking and Reasoning. (ed) Holyoak,
4	Problem solving and Design	Jonassen, D., J. Strobel, and C. B. Lee. 2006. Everyday Problem Solving in Engineering: Lessons for Engineering Educators. *Journal of Engineering Education* April:139-151. Dym, C., A. Agogino, O. Eris, D. Frey, and L. Leifer. 2005. Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education* 94 (1):103-120.
5	Mental Models and Multimedia	Johnson-Laird, P. N. 1980. Mental Models in Cognitive Science. *Cognitive Science: A Multidisciplinary Journal* 4:71-115. Schwartz, D. L., Blair, K. P., Biswas, G., Leelawong, K., & Davis, J. ((2008)). ANIMATIONS OF THOUGHT: INTERACTIVITY IN THE TEACHABLE AGENT PARADIGM. In R. Lowe & W. Schnotz (Eds.), Learning with Animation: Research and Implications for Design. UK: Cambridge University Press. Mayer R. (2006). Coping with Complexity in Multimedia Learning. Handling Complexity in Learning Environments: Theory and Research. Hoffman, B. & Ritchie, D. (1997). Using multimedia to overcome the problems with problem based learning. *Instructional Science* 25: 97–115.
6	Reasoning with models	Lehrer, R., and L. Schauble. 2000. Developing Model-Based Reasoning in Mathematics and Science. *Journal of Applied Developmental Psychology* 21 (1):39-48. Penner, D. E., R. Lehrer, and L. Schauble. 1998. From Physical Models to Biomechanics: A Design-Based Modeling Approach. *Journal of the Learning Sciences* 7 (3/4):429. Hmelo-Silver, C. E., and M. G. Pfeffer. 2004. Comparing Expert and Novice Understanding of a Complex System from the Perspective of Structures, Behaviors, and Functions. *Cognitive Science* 28 (1):127-138.

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Week	Major Topic	Tentative Readings
7	Simulations and computational tools	de Jong, T. & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research* 68(2): 179–201. Njoo, Melanie and De Jong, Ton (2006). Exploratory learning with a computer simulation for control theory: Learning processes and instructional support. *Journal of Research in Science Teaching*, 30(80). Sedig, K. and Liang, H. (in press) "Interactivity of visual mathematical representations: Factors affecting learning and cognitive processes". *Journal of Interactive Learning Research.* Swaak, J.,&de Jong, T. (2001). Discovery simulations and the assessment of intuitive knowledge. *Journal of Computer Assisted Learning*, 17, 284–294.
8	Metacognition and Self regulations	Mayer, R. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science* 26: 40–63. Sternberg, R. (1998). Metacognition, abilities, and developing expertise: What makes an expert student? *Instructional Science* 26: 127–140. Winne, P.H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology* 89(3): 397–410. Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist* 34: 906–911.
9	Expertise and Transfer	Bransford, J. D., & Schwartz, D. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, 24, 61-100. Chi, M.T.H., Glaser, R. & Farr, M. (1988). *The Nature of Expertise.* Hillsdale, NJ: Erlbaum. Chi, M. T. H., R. Glaser, and E. Rees. 1982. Expertise in Problem Solving. In *In Advances in the Psychology of Human Intelligence*, edited by R. J. Sternberg. Hillsdale, NJ: Erlbaum.
10	SPRING BREAK	

Week	Major Topic	Tentative Readings
11	Socially Shared Cognitive Tools	Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Educational Researcher*, 18(1), 32-42. Susanne P. Lajoie, Claudia Guerrera, Steven D. Munsie, Nancy C. Lavigne, Constructing knowledge in the context of BioWorld, *Instructional Science*, Volume 29, Issue 2, Mar 2001, Pages 155 – 186 Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive Apprenticeship: Making Thinking Visible. *American Educator*, 6(11), 38-46.
12	Serious gaming, edutainment and Virtual Reality	Squire, K. (2003). Video games in education. *International Journal of Intelligent Simulations and Gaming, 2*(1), 49-62. Gee, J. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.
13	Artificial Intelligence and Teachable Agents/ intelligent tutors	Biswas, G., Leelawong, K., Schwartz, D., & Vye, N. (2005). LEARNING BY TEACHING: A NEW AGENT PARADIGM FOR EDUCATIONAL SOFTWARE. *Applied Artificial Intelligence*, 19(3/4), 363-392. Blair, K., Schwartz, D. L., Biswas, G., & Leelawong, K. (in press). Pedagogical Agents for Learning by Teaching: Teachable Agents. *Educational Technology*. Merrill, D., Reiser, B., Merrill, S. & Landes, S. (1995). Tutoring: Guided learning by doing. *Cognition and Instruction* 13(3): 315–372.
14	Spatial reasoning and Perceptual Learning	Lajoie, S.P. (1991). Reality testing for cognitive strategy research. *Educational Researcher* 20(3): 30–33. Hsi, S., M. Linn, and J. Bell. 1997. The Role of Spatial Reasoning in Engineering and the Design of Spatial Instruction. *Journal of Engineering Education*:151-158.
15	Pros and Cons of Cognitive Devices	
16	Student Presentations	
	Finals weeks	

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.)
http://www.gradschool.purdue.edu/downloads/Graduate_School_Policies_and_Procedures_Manual.pdf

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

ENE 63000

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

ENE 63000

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.

[signature]

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. Cipra

ENE 63000

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

Week	Major Topic	Tentative Readings
1	Introduction - Cognition, Devices and STEM Thinking	
2	Introduction to CD continued – exploring the role of technology and cognition. Productivity versus learning	Pea, R.D. (1985). Beyond amplification: Using the computer to reorganize mental functioning. *Educational Psychologist*,20: 167–182. Salomon, G., Perkins, D.N. & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher* 20: 10–16.
3	Mindtools, Model of Conceptual Understanding for learning	Jonassen, D.H. (2000) Computers as Mindtools for Schools: engaging critical thinking, 2nd Ed. Upper Saddle River: Prentice Hall. Linn, M. 2003. Technology and science education: starting points, research programs, and trends. *International Journal of Science Education* 25 (6):727 - 758. Jonassen, D.H. (1996) Computers in the Classroom: mindtools for critical thinking. Columbus: Merrill/Prentice Hall.
4	Mindtools (continued)	Discussion on the range of mindtools, exploring examples and defining possibilities for STEM related mind tools.

Week	Major Topic	Tentative Readings
5	Problem solving and Design	Jonassen, D., J. Strobel, and C. B. Lee. 2006. Everyday Problem Solving in Engineering: Lessons for Engineering Educators. *Journal of Engineering Education* April:139-151. Dym, C., A. Agogino, O. Eris, D. Frey, and L. Leifer. 2005. Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education* 94 (1):103-120.
6	Mental Models and Multimedia	Ramadas, J. (2009)Visual and Spatial Models in Science Learning. International Journal of Science Education. 31(3), pp 301-318. Nersessian, N. (1999). Model-Based Reasoning in Conceptual Change. In Model-Based Reasoning in Scientific Discovery, L. Magnani, N.J. Nersessian, and P. Thagard, Kluwer Academic/Plenum Publishers: NY. Hegarty, M (2004). Mechanical reasoning by mental simulation. TRENDS in Cognitive Sciences. 8(6). Pp 280-284.
7	Reasoning with models	Lehrer, R., and L. Schauble. 2000. Developing Model-Based Reasoning in Mathematics and Science. *Journal of Applied Developmental Psychology* 21 (1):39-48. Johnson-Laird, P.N., Girotto, V. and Legrenzi, P. (1998). Mental Models: A gentle guide for outsiders. http://icos.groups.si.umich.edu/gentleintro.html Penner, D. E., R. Lehrer, and L. Schauble. 1998. From Physical Models to Biomechanics: A Design-Based Modeling Approach. *Journal of the Learning Sciences* 7 (3/4):429.
8 (3/3)	Simulations and computational tools	de Jong, T. & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research* 68(2): 179–201. Njoo, Melanie and De Jong, Ton (2006). Exploratory learning with a computer simulation for control theory: Learning processes and instructional support. Journal of Research in Science Teaching, 30(80). Sedig, K. and Liang, H. (in press) "Interactivity of visual mathematical representations: Factors affecting learning and cognitive processes". *Journal of Interactive Learning Research.* Swaak, J.,&de Jong, T. (2001). Discovery simulations and the assessment of intuitive knowledge. Journal of Computer Assisted Learning, 17, 284–294.
9	Visualization Data	Tversky, Barbara (2004). Visuospatial Reasoning. The Cambridge Handbook of Thinking and Reasoning. (ed) Holyoak, Roth, W.-M. & McGinn, M.K. (1997). Graphing: Cognitive ability or practice? Science Education 81(1): 91–106. Thomas, JJ Cook Kristin (2005). Visual Representations (Chapter 3). In Thomas and Cook (Eds) Illuminating the Path. National Visualization and Analytics Center. IEEE. http://nvac.pnl.gov/docs/RD_Agenda_VisualAnalytics.pdf
	SPRING BREAK	

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Week	Major Topic	Tentative Readings
10	Expertise and Transfer	Schwartz, D., Bransford, J. D., & Sears, D. (1999). Rethinking transfer: A simple proposal with multiple implications. Review of Research in Education, 24, 61-100. Chi, M.T.H., Glaser, R. & Farr, M. (1988). *The Nature of Expertise*. Hillsdale, NJ: Erlbaum. Bransford, J. D., & Schwartz, D. (1999). Rethinking transfer: A simple proposal with multiple implications. Review of Research in Education, 24, 61-100. Chi, M. T. H., R. Glaser, and E. Rees. 1982. Expertise in Problem Solving. In *In Advances in the Psychology of Human Intelligence*, edited by R. J. Sternberg. Hillsdale, NJ: Erlbaum.
11	Metacognition and Self regulations	Mayer, R. (1998). Cognitive, metacognitive, and motivational aspects of problem solving. *Instructional Science* 26: 40–63. Sternberg, R. (1998). Metacognition, abilities, and developing expertise: What makes an expert student? *Instructional Science* 26: 127–140. Winne, P.H. (1997). Experimenting to bootstrap self-regulated learning. *Journal of Educational Psychology* 89(3): 397–410. Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitivedevelopmental inquiry. *American Psychologist* 34: 906–911.
12	Socially Shared Cognitive Tools	Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. Educational Researcher, 18(1), 32-42. Susanne P. Lajoie, Claudia Guerrera, Steven D. Munsie, Nancy C. Lavigne, Constructing knowledge in the context of BioWorld, Instructional Science, Volume 29, Issue 2, Mar 2001, Pages 155 – 186 Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive Apprenticeship: Making Thinking Visible. American Educator, 6(11), 38-46.
13	Serious gaming and edutainment Virtual Reality	Squire, K. (2003). Video games in education. International Journal of Intelligent Simulations and Gaming, 2(1), 49- 62. Gee, J. (2003). What video games have to teach us about learning and literacy. New York: Palgrave Macmillan.
14	Artificial Intelligence and Teachable Agents/ intelligent tutors	Biswas, G., Leelawong, K., Schwartz, D., & Vye, N. (2005). LEARNING BY TEACHING: A NEW AGENT PARADIGM FOR EDUCATIONAL SOFTWARE. Applied Artificial Intelligence, 19(3/4), 363-392. Blair, K., Schwartz, D. L., Biswas, G., & Leelawong, K. (in press). Pedagogical Agents for Learning by Teaching: Teachable Agents. Educational Technology. Merrill, D., Reiser, B., Merrill, S. & Landes, S. (1995). Tutoring: Guided learning by doing. Cognition and Instruction 13(3): 315–372.

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Week	Major Topic	Tentative Readings
15	Student Presentations	
16	Finals weeks	Final paper due

Optional topic

	Spatial reasoning and Perceptual Learning	Lajoie, S.P. (1991). Reality testing for cognitive strategy research. Educational Researcher 20(3): 30–33. Hsi, S., M. Linn, and J. Bell. 1997. The Role of Spatial Reasoning in Engineering and the Design of Spatial Instruction. *Journal of Engineering Education*:151-158.

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%.