Center for Excellence in Teaching and Learning
University of New Hampshire

The University of New Hampshire's Teaching and Learning Center: Applying Science of Learning with STEM Faculty

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Conference at the Interface of Discipline-Based Education Research in STEM and Psychological Science

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Two-Part Multimedia Presentation

- Part 1: I will have words, both written and spoken.
- Part 2: Multimedia part, with words (written and spoken) and graphics.
  - Catherine Overson will present three examples of our in-vivo studies in STEM that illustrate our approach and show the beneficial impact of our cognitively-based intervention strategies.

History of Our Center's Work on Applying the Science of Learning

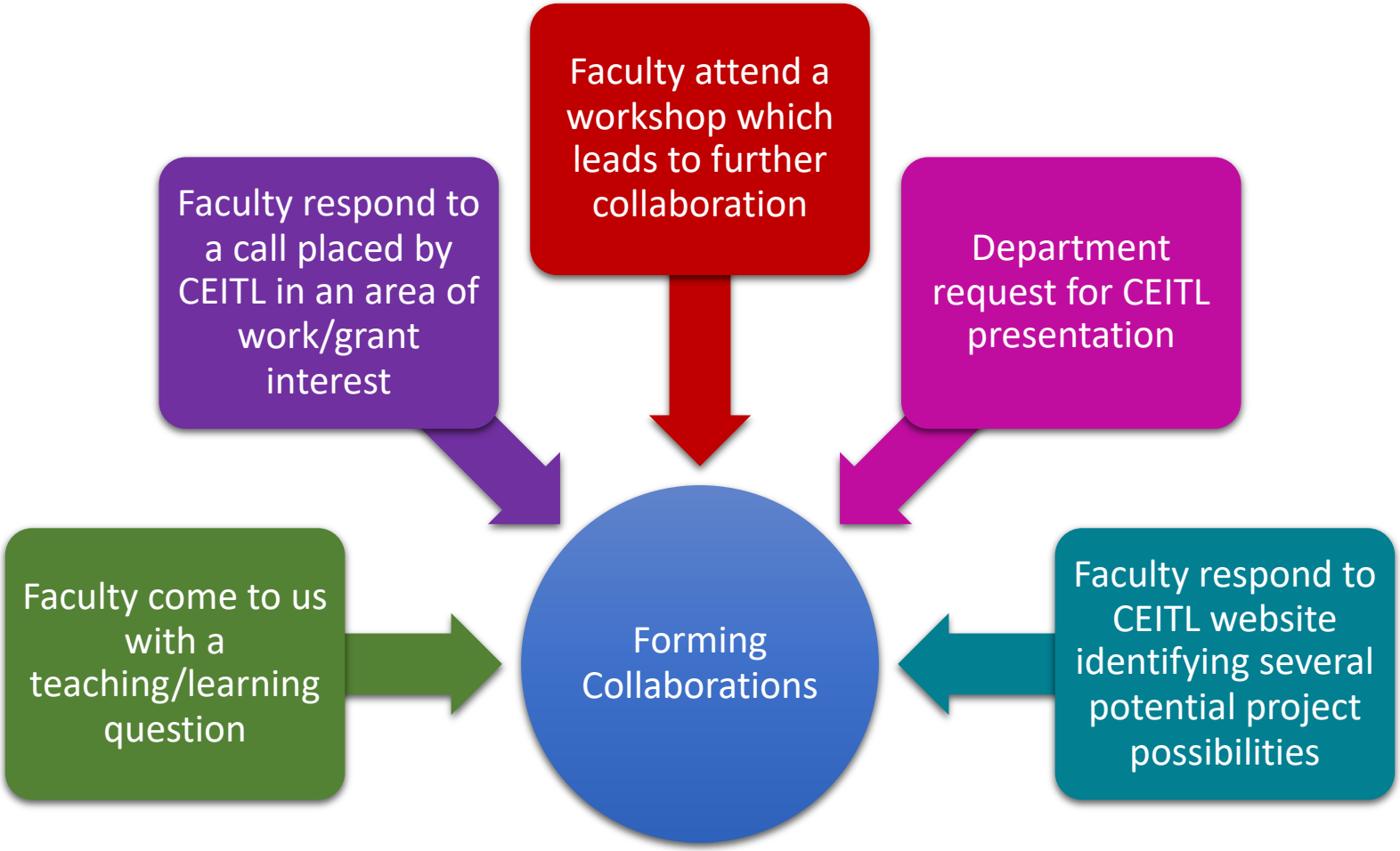
We have worked with faculty over the **past 10 years** to design, implement, and assess the impact of cognitively-based instructional methods in courses university-wide, including in STEM.

- Funded by the Davis Educational Foundation.

Center Staff

- director
- associate director
- science of learning project coordinator
- assessment coordinator
- research associates

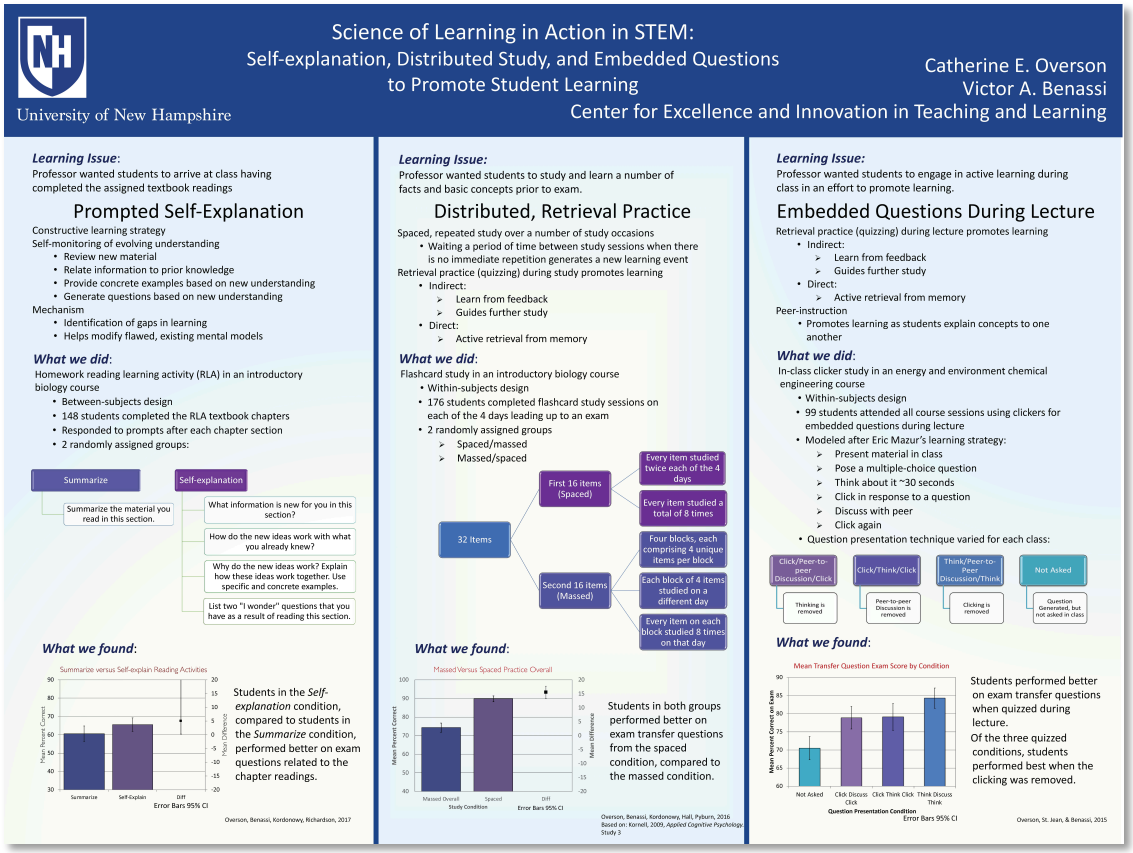
Events Leading to CEITL/Faculty Collaborations



Stepped Process

If a project, CEITL staff will:

1. Design
2. Implement
3. Assess learning impact of our selected intervention



University of New Hampshire

Science of Learning in Action in STEM:
Self-explanation, Distributed Study, and Embedded Questions to Promote Student Learning

Catherine E. Overson
Victor A. Benassi
Center for Excellence and Innovation in Teaching and Learning

Learning Issue:
Professor wanted students to arrive at class having completed the assigned textbook readings

Prompted Self-Explanation

Constructive learning strategy
Self-monitoring of evolving understanding
- Review new material
- Relate information to prior knowledge
- Provide concrete examples based on new understanding
- Generate questions based on new understanding

Mechanism
- Identification of gaps in learning
- Helps modify flawed, existing mental models

What we did:
Homework reading learning activity (RLA) in an introductory biology course
- Between-subjects design
- 148 students completed the RLA textbook chapters
- Responded to prompts after each chapter section
- 2 randomly assigned groups:

Summarize
Summarize the material you read in this section.

Self-explanation
What information is new for you in this section?
How do the new ideas work with what you already knew?
Why do the new ideas work? Explain how these ideas work together. Use specific and concrete examples.
List two "I wonder" questions that you have as a result of reading this section.

What we found:

Summarize versus Self-explain Reading Activities

Mean Percent Correct / Mean Difference

Summarize | Self-Explain | Diff

Error Bars 95% CI

Students in the *Self-explanation* condition, compared to students in the *Summarize* condition, performed better on exam questions related to the chapter readings.

Overson, Benassi, Kordonowy, Richardson, 2017

Learning Issue:
Professor wanted students to study and learn a number of facts and basic concepts prior to exam.

Distributed, Retrieval Practice

Spaced, repeated study over a number of study occasions
- Waiting a period of time between study sessions when there is no immediate repetition generates a new learning event

Retrieval practice (quizzing) during study promotes learning
- Indirect:
  - Learn from feedback
  - Guides further study
- Direct:
  - Active retrieval from memory

What we did:
Flashcard study in an introductory biology course
- Within-subjects design
- 176 students completed flashcard study sessions on each of the 4 days leading up to an exam
- 2 randomly assigned groups
  - Spaced/massed
  - Massed/spaced

32 items

First 16 items (Spaced)
- Every item studied twice each of the 4 days
- Every item studied a total of 8 times

Second 16 items (Massed)
- Four blocks, each comprising 4 unique items per block
- Each block of 4 items studied on a different day
- Every item on each block studied 8 times on that day

What we found:

Massed Versus Spaced Practice Overall

Mean Percent Correct / Mean Difference

Massed Overall | Spaced | Diff

Study Condition

Error Bars 95% CI

Students in both groups performed better on exam transfer questions from the spaced condition, compared to the massed condition.

Overson, Benassi, Kordonowy, Hall, Pyburn, 2016
Based on: Kornell, 2009, *Applied Cognitive Psychology*, Study 3

Learning Issue:
Professor wanted students to engage in active learning during class in an effort to promote learning.

Embedded Questions During Lecture

Retrieval practice (quizzing) during lecture promotes learning
- Indirect:
  - Learn from feedback
  - Guides further study
- Direct:
  - Active retrieval from memory

Peer-instruction
- Promotes learning as students explain concepts to one another

What we did:
In-class clicker study in an energy and environment chemical engineering course
- Within-subjects design
- 99 students attended all course sessions using clickers for embedded questions during lecture
- Modeled after Eric Mazur's learning strategy:
  - Present material in class
  - Pose a multiple-choice question
  - Think about it ~30 seconds
  - Click in response to a question
  - Discuss with peer
  - Click again
- Question presentation technique varied for each class:

Click/Peer-to-peer Discussion/Click — Thinking is removed
Click/Think/Click — Peer-to-peer Discussion is removed
Think/Peer-to-Peer Discussion/Think — Clicking is removed
Not Asked — Question Generated, but not asked in class

What we found:

Mean Transfer Question Exam Score by Condition

Mean Percent Correct on Exam

Not Asked | Click Discuss Click | Click Think Click | Think Discuss Think

Question Presentation Condition

Error Bars 95% CI

Students performed better on exam transfer questions when quizzed during lecture.
Of the three quizzed conditions, students performed best when the clicking was removed.

Overson, St. Jean, & Benassi, 2015

- Visit Catherine Overson's poster presentation to learn about three examples of in-vivo projects we have done in STEM areas.

General Observations

- Our work is based on the notion of ‘transfer appropriate instruction’ (cf. Mark McDaniel).
- Best illustrated by Ken Koedinger’s and colleagues knowledge- learning-instruction framework.
  - K.R. Koedinger, A.T. Corbett,& C. Perfetti. (2012). The knowledge-learning-instruction framework: Bridging the science- practice chasm to enhance robust student learning. *Cognitive Science, 36*, 757–798.

General Observations

We have been impressed that the interventions we have examined have often—usually—produced **"main effects"**

- retrieval practice promotes learning, retention, and transfer;
- spacing of study promotes better exam performance than massed study;
- self-explanation of textbook material leads to better exam performance than summarization of that material; etc.

General Observations

Given the nature and amount of ‘noise’ involved in this kind of work, it is impressive that consistent and sometimes robust effects are found.

General Observations

- **However, these interventions are not always equally effective for all students**.
- Examples:
  - Concept maps and background knowledge
  - guiding questions and reading skill (Stiegler-Balfour and Benassi)
  - retrieval practice and overall academic skill.

General Observations

- **However, these interventions are not always equally effective for all students**.
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General Observations

Other examples:

- Elizabeth Bjork, Robert Bjork and colleagues: redundancy in multi-media presentations
- Faria Sana, Joe Kim, and colleagues: effects of blocking and interleaving of practice. Some conditions blocking . . .
- Paulo Carvahlo, Rob Goldsteone, and colleagues: self-regulation of study—benefits of blocking of study for students who choose to block.

Next set of challenges for teaching and learning centers and for science of learning researchers

End