Science of Learning Centers Program (SLC) : A Status Report

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Program Director, and Chair of Coordinating Committee
Science of Learning Centers Program

SBE Advisory Committee Meeting
November 8, 2007

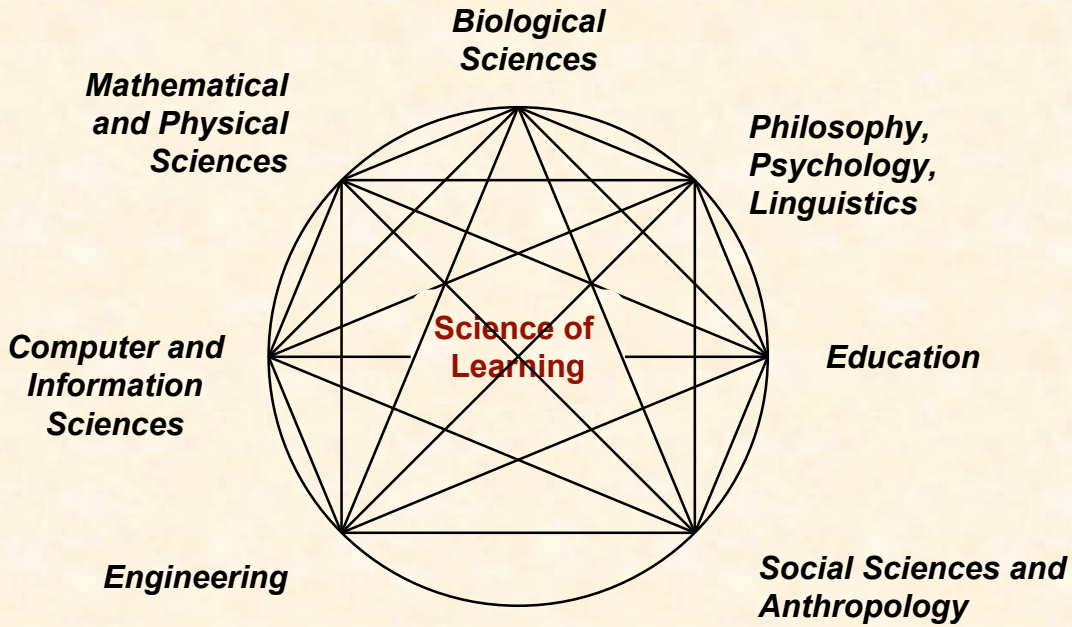
OVERVIEW

- SLC Program and Goals
- Portfolio

  Added value: Centers and Network of Centers
- Recent activities
- Management

SCIENCE OF LEARNING CENTERS PROGRAM

Learning in animals, humans and machines



intersections and integration of diverse disciplines

The goals of the SLC program are:

- **to advance the frontiers**
  of all the sciences of learning through integrated research
- **to connect this research**
  to specific scientific, technological, educational, and workforce challenges
- **to enable research communities**
  that can capitalize on new opportunities and discoveries and respond to new challenges

THE CENTERS PORTFOLIO

PI Name Center	Unifying Focus	Research Approaches	Disciplines/Research Communities
PI John Bransford LIFE – **Learning in Informal and Formal Environments**	**Social Foundations of learning in informal and formal environments**	**Behavioral and socio-cultural approaches, neuroi-maging**	**Education, psychology, cognitive neuroscience, learning technologies**
PI Stephen Grossberg **CELEST-Center for Cognitive and Educational Neuroscience**	**Modeling and experimentation to understand real time autonomous learning**	**Quantitative behavioral, mathematical modeling and statistical methods, neuro-physiological recordings, neuro-imaging**	**Computational neuroscience and neurobiology, cognitive sciences, engineering, machine learning, robotics**
PI Ken Koedinger **PSLC – Pittsburgh Science of Learning Center**	**Studying robust learning with learning experiments in real classrooms**	**Classroom and laboratory studies, data analysis tools, longitudinal microgenetic data**	**Computer science, cognitive psychology, human computer interaction, machine learning, robotics**
PI Thomas Allen **VL2 – Visual Language and Learning Center**	**Learning processes of visual languages and their applications for language processing**	**Behavioral, socio-cultural, neuro-imaging**	**Neuroscience, cognitive psychology, linguistics, computer science and education**
PI Garrison Cottrell **TDLC – Temporal Dynamics of Learning Center**	**Time as a factor in learning processes**	**Behavioral, social, neuro-physiological recordings, neuro-imaging, cell/molecular and neuro-anatomical methods,**	**Neurobiology, cognitive sciences, computational neuroscience, machine learning, robotics , education**
PI Nora Newcombe **SILC**	**Space as a factor in learning processes**	**Behavioral, neuro-imaging**	**Cognitive science, computer science, education**

LIFE: Learning in Informal & Formal Environments

To develop and test principles about the social foundations of human learning in informal and formal environments, including how people learn to innovate in contemporary society, with the goal of enhancing human learning from infancy to adulthood

Director : John Bransford
Co-Director: Patricia Kuhl

University of Washington

Stanford University

SRI International

3 Strategic Driving Questions

- Social Foundations

  Basic processes and mechanisms –domains, context and development

- Social Practices

  Barriers and Bridges

- Social in Designs

  From theory to practice – Designs that enhance learnig

Center of Excellence for Learning in Education, Science, and Technology (CELEST)

AUTONOMOUS REAL-TIME LEARNING SYSTEMS

how the brain autonomously learns to control complex behavior in real time in changing world

Director : Stephen Grossberg
Co-Directors: Ennio Mingolla, Michael Hasselmo

Boston University
Brandeis University
Massachusetts Institute of Technology
University of Pennsylvania

Science of Learning Centers

A simple task requires perception-cognition-emotion-action cycle involving visual, temporal, parietal, prefrontal cortices…

	THRUSTS
Spatially orient to the cup	3
See cup	1
Recognize cup	1
Want to pick cup up	3
Plan to pick cup up	3,5
Pick cup up	1,3,5

- Learning in audition, speech and language
- Learning in cognitive-emotional interactions and planned sequential behaviors
- Learning in episodic memory: encoding and retrieval
- Learning in concept formation and rule discovery
- Learning in attentive recognition and neuromorphic technology
- Learning in visual perception and recognition
- Educational modules and outreach
- Diversity outreach

CELEST LONG-RANGE RESEARCH GOAL

Develop biologically-inspired, general-purpose, real-time, autonomous adaptive systems for processing huge amounts of data in unpredictably changing environments.

VISUAL INTELLIGENCE

- Visual perception
- Object recognition
- Visually-based cognition
- Visually-based emotion
- Visually-based planning
- Spatial navigation
- Eye movement tracking

AUDITORY INTELLIGENCE

- Auditory streaming
- Auditory perception
- Speech recognition
- Speech production
- Language understanding
- Language-based cognition
- Language-based emotion

Pittsburgh Science of Learning Center (PSLC)

PURPOSE

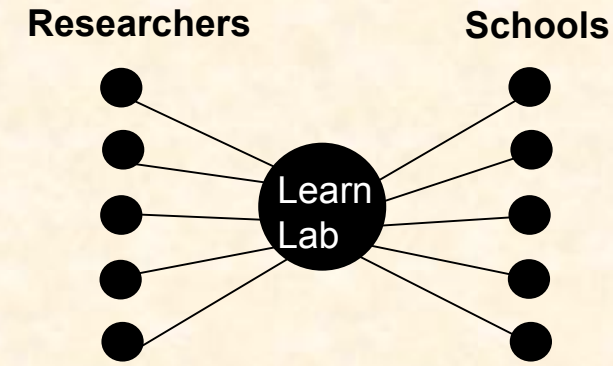
- **To yield theoretically sound and useful principles of *robust learning*,**
- ***LearnLab*, an international resource that combines *technology, data stores, basic cognitive research, and classroom testbeds***
- **to facilitate *in vivo learning experimentation*.**

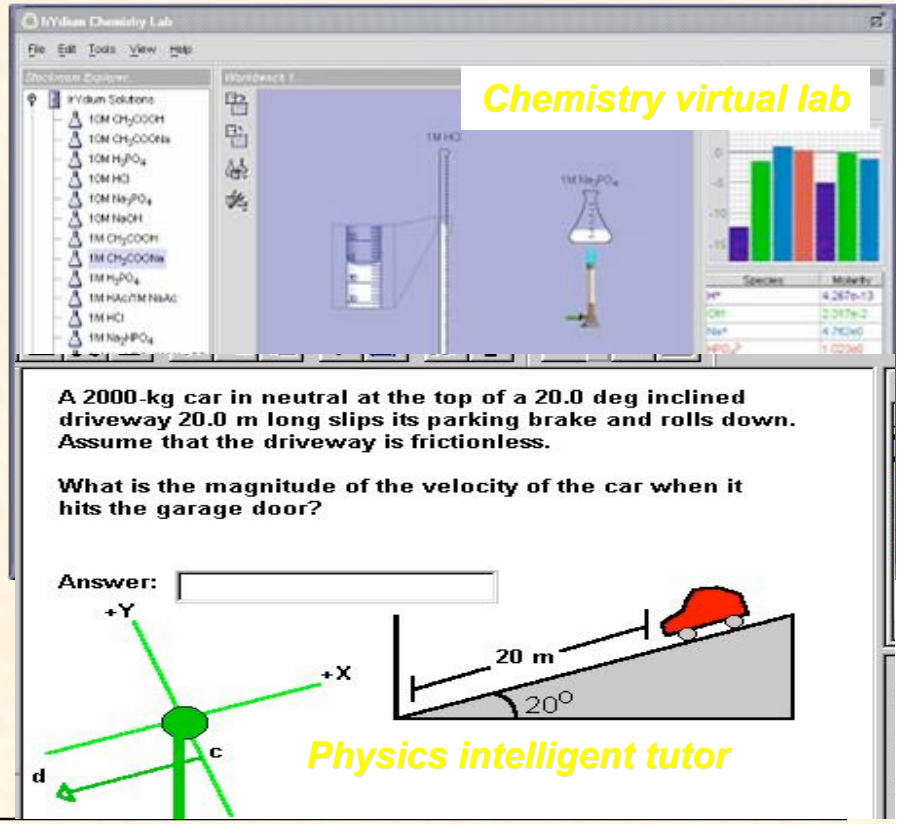
Ken Koedinger **- Carnegie Mellon Co-Director**
Kurt VanLehn **- Univ of Pittsburgh Co-Director**
Charles Perfetti **- Chief Scientist**

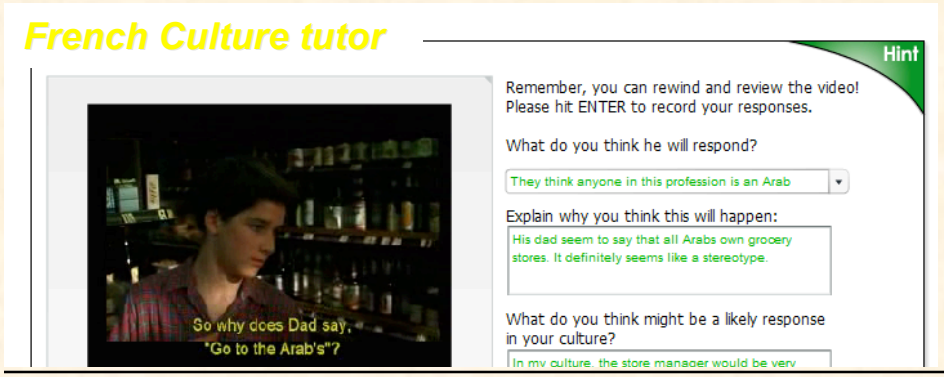
LearnLab
Pittsburgh Science of Learning Center

LearnLab courses at K12 & College Sites

- ***7 cyber-enabled* courses:** Chemistry, Physics, Algebra, Geometry, French, Chinese, English
- ***Made open for research***
  - ✓ *Use procedures*: **Course committee, site MOUs, IRB**
  - ✓ *Data collection*: **Ed tech, tests, homework…**







Science of Learning Centers

Science of Learning Center on Visual Language and Visual Learning (VL2)

To gain a greater understanding of the biological, linguistic, sociocultural and pedagogical conditions that influence the acquisition of language and knowledge through visual modality in order to promote optimal practices in education

Director: Thomas Allen

Co-Directors: Guinevere Eden

David Corinna

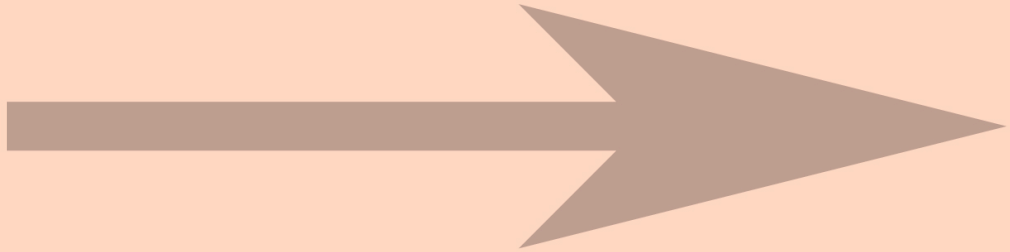
- Gallaudet University
- Boston University
- Georgetown University
- Rochester Institute of Technology
- University of California at Davis
- University of Illinois at Urbana0champaign
- University of New Mexico

Science of Learning Centers

Framework

VL2 Research Initiatives and Theoretical and Methodological Domains

	Cognitive Neuroscience	Development & Socialization	Language Structure & Visual Modality
Visual language acquisition			
Literacy development			
Inter-language and inter-modal language mapping			
Research-to-practice integration			
Diversity			
Computational/human studies infrastructure			



TEMPORAL DYNAMICS OF LEARNING CENTER (TDLC)

- **To achieve an integrated understanding of the role of time and timing in learning, across multiple scales, brain systems, and social systems**

Director: Garrison Cottrell

Co-Directors: Andrea Chiba

Terry Sejnowski

WHY DOES TIME MATTER?

- **Time matters for processing (input dynamics)**
  - ✓ Rapid Auditory Processing (RAP) thresholds predict later language impairments
- **Time matters for remembering (brain dynamics)**
  - ✓ Consolidation during sleep is necessary for storage
- **Time matters for learning (brain dynamics)**
  - ✓ The spacing of study episodes predicts later test scores
  - ✓ Precise spike timing is necessary for LTP
- **Time matters for teaching (output dynamics)**
  - ✓ Positive feedback that comes too late is, well, too late!

Theoretical models capable of spanning time-scales

The Network-of-Networks Solution

UC San Diego

Rutgers University

Vanderbilt University

UC Berkeley

University of Colorado

The Salk Institute

Queensland University

Victoria University

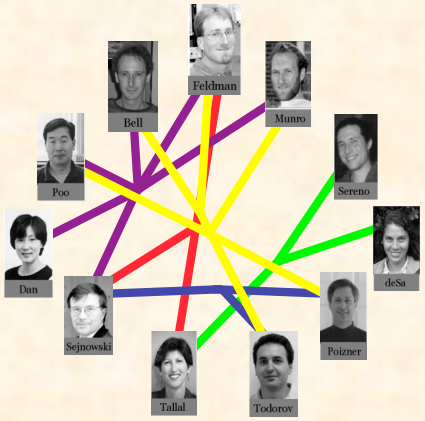
Brown University

Carnegie-Melon University

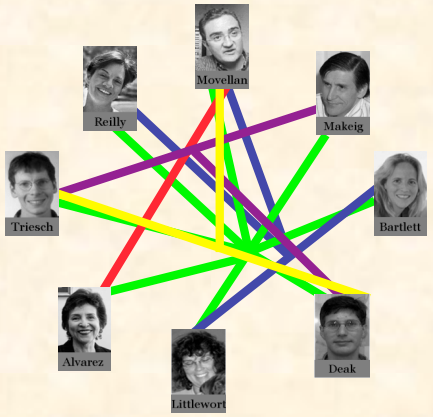
Yale University

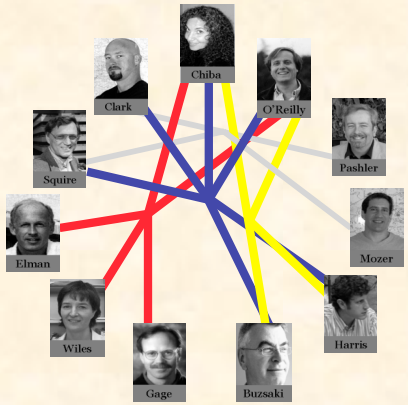
San Diego State University

SensoriMotor Network



Social Interaction Network





Bridge Members

Interacting Memory Systems

Perceptual Expertise Network

Mathematics

Physics

Machine Learning

Robotics

Computer Science

Computational Neuroscience

Neuroscience

Cognitive Science

Linguistics

Neuropsychology

Cognitive Psychology

Developmental Psychology

Learning Theory

Education

Science of Learning Centers

Spatial Intelligence and Learning Center (SILC)

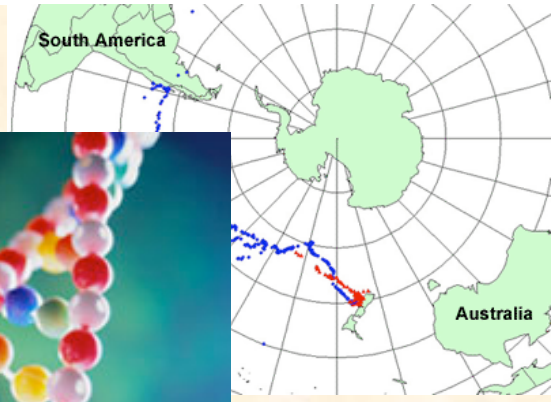
To understand and improve human spatial intelligence: how spatial knowledge and reasoning processes are learned, how they interact with symbolic systems, how they contribute to reasoning and learning in non-spatial domains, and how they support learning in science, technology, engineering and mathematics (STEM)

Nora S. Newcombe, PI
Temple University
Dedre Gentner, Co-PI
Northwestern University
Susan Goldin-Meadow, *Co-PI*
University of Chicago
Larry V. Hedges, *Co-PI*
Northwestern University
Susan C. Levine, Co-PI
University of Chicago

Science of Learning Centers

- **Spatial intelligence is critically important**

  Graphs and diagrams
  Analogy and metaphor
  Inference



- **Spatial thinking is largely learned and can be radically improved**

What spatial processes matter in STEM education?

How do external representations influence spatial learning?

What spatial processees and representations are malleable?

More Specific Goals

- Understanding spatial processes
  - ✓ malleability
  - ✓ variability
  - ✓ developmental trajectories.
- Identifying key spatial skills for STEM disciplines.
- Developing data, expertise, and curriculum materials for supporting spatial learning
- Creating new tools for cognitive science research and for supporting education involving spatial domains
- Raising the visibility of spatial cognition as a new sub-discipline, attracting a diverse and interdisciplinary set of researchers and practitioners

Added Value of Centers and a Network of Centers

- Critical mass of experts
- Transdisciplinary, multi-pronged, multilevel experimentation and data analysis – common language, standards
- Timely and effective communication and synthesis
- Duration of funding
- Resources and infrastructure

- Education and training – critical mass of students who share common interests in interdisciplinary training, teamwork

- Knowledge Transfer and Dissemination – critical mass and stability

Emerging cross-cutting themes

Language, Speech, and Bilingualism	CELEST	LIFE	PSLC	TDLC	SILC	VL2
HCI and e-Learning Technologies	CELEST	LIFE	PSLC		SILC	
Visual Perception and Cognition	CELEST		PSLC	TDLC	SILC	
Emotions and Motivation	CELEST	LIFE		TDLC		
Transfer and expertise		LIFE	PSLC	TDLC		
Social Interactivity		LIFE	PSLC			
Sensory-motor learning	CELEST			TDLC		
Representational/ symbolic systems		LIFE			SILC	VL2
Metacognitive issues		LIFE	PSLC			
Spatial cognition					SILC	VL2
Memory	CELEST			TDLC		

Catalyst Awards

To support limited-duration, research and partnership-building activities designed to prepare groups to subsequently compete for Centers. Awards of up to $250,000 each.

- **22 awards from 2 competitions**

  Neural basis of learning (2)

  Learning Technologies, engineering and human computer-interactions (5)

  Disabled Access to Learning (2)

  Perception, Cognition and Development (9)

  Sociocultural context of Learning (4)

FY2007 activities:

- **Program Review and Management**
  - ✓ Start-up of new centers, strategic planning etc
  - ✓ Annual review of centers, PI meeting

Program Development – Worshop Series
- ✓ Transfer, Expertise, Innovation and Creativity
- ✓ Science and Engineering of Learning
- ✓ Language Learning and Education
- ✓ Educational Neuroscience

- **Funding Opportunities:**
  - ✓ Supplements to NSF awards (non-SLC)
  - ✓ Small Grants for Exploratory Research (SGER)
  - ✓ Workshops

FY 2008 ACTIVITIES

- **Program Review and Management**
  - ✓ External and Internal Review of current centers
  - ✓ Renewal of Cohort #1 centers
  - ✓ Full funding of Cohort #2 centers

  - ✓ Committee of Visitors review
  - ✓ Program Review

- **Program Development:**
  - ✓ Capacity building: Arts and Learning in STEM
  - ✓ Development of Cyberinfrastructure
  - ✓ Development of international connections

SLC Program Management

SLC Program Officers:

Soo-Siang Lim

Maria Kozhevnikov

Coordinating Committee

SBE: Soo-Siang Lim, Chair
Maria Kozhevnikov
Chris Kello
Jennifer Brostek
BIO: Steve De Belle

CISE: Douglas Fisher
EHR: John Cherniavsky
ENG: Bruce Kramer

MPS: Michael Clarke
OCI: TBD
OISE: Rose Gombay
BFA: Elizabeth Blue

Management of individual centers

VL2: SBE
Chris Kello (SBE)
Carol Van Haartesveldt (E HR)

SILC: SBE
Maria Kozhevnikov (SBE)
Mary Lou Maher (CISE)
Chris Kello (SBE)

TDLC: BIO
Steve De Belle (BIO)
Michael Clarke (MPS)

PSLC: CISE
Amy Baylor (CISE)
Douglas Fisher (CISE)

LIFE: EHR
John Cherniavsky (E HR)
Maria Kozhevnikov (SBE)

CELEST: ENG
Kishan Baheti (ENG)
Maria Kozhevnikov (SBE)