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

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

Science of Learning Centers
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 learning
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
A simple task requires perception-cognition-emotion-action cycle involving visual, temporal, parietal, prefrontal cortices…

**THRUSTS**

<table>
<thead>
<tr>
<th>Spatially orient to the cup</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>See cup</td>
<td>1</td>
</tr>
<tr>
<td>Recognize cup</td>
<td>1</td>
</tr>
<tr>
<td>Want to pick cup up</td>
<td>3</td>
</tr>
<tr>
<td>Plan to pick cup up</td>
<td>3,5</td>
</tr>
<tr>
<td>Pick cup up</td>
<td>1,3,5</td>
</tr>
</tbody>
</table>

- 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 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...

French Culture tutor

Hints:

- Remember, you can rewatch and review the video. Please use the buttons to record your responses.
- What do you think he will respond?
- They think anyone in this profession is an Arab
- Explain why you think this will happen:
  - He's trying to say that all Arabs own grocery stores. It definitely seems like a stereotype.
- What do you think might be a likely response in your culture?
  - In my culture, the store manager would be very...
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 Urbana-Champaign
- University of New Mexico
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

Science of Learning Centers
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 learning (brain dynamics)
  - The spacing of study episodes predicts later test scores
  - Precise spike timing is necessary for LTP

- Time matters for remembering (brain dynamics)
  - Consolidation during sleep is necessary for storage

- 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

Mathematics
Physics
Machine Learning
Robotics
Computer Science
Computational Neuroscience
Neuroscience
Cognitive Science
Linguistics
Neuropsychology
Cognitive Psychology
Developmental Psychology
Learning Theory
Education

SensoriMotor Network
Social Interaction Network

Interacting Memory Systems
Perceptual Expertise Network

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
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 processes 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

<table>
<thead>
<tr>
<th>Theme</th>
<th>CELEST</th>
<th>LIFE</th>
<th>PSLC</th>
<th>TDLC</th>
<th>SILC</th>
<th>VL2</th>
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<tbody>
<tr>
<td>Language, Speech, and Bilingualism</td>
<td>CELEST</td>
<td>LIFE</td>
<td>PSLC</td>
<td>TDLC</td>
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<tr>
<td>HCI and e-Learning Technologies</td>
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<td>LIFE</td>
<td>PSLC</td>
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<td>SILC</td>
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<tr>
<td>Visual Perception and Cognition</td>
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<td>SILC</td>
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<td>Emotions and Motivation</td>
<td>CELEST</td>
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<td>Transfer and expertise</td>
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<td>Sensory-motor learning</td>
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<tr>
<td>Representational/symbolic systems</td>
<td>LIFE</td>
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<td>SILC</td>
<td>VL2</td>
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<td>Metacognitive issues</td>
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<td>PSLC</td>
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<td>Spatial cognition</td>
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<td>SILC</td>
<td>VL2</td>
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<tr>
<td>Memory</td>
<td>CELEST</td>
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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 – Workshop 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)