Innovation in Education
Connecting How we Learn to Educational Practice and Policy: Research Evidence and Implications

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Presentation Abstracts - The Science of Learning Centers

Exploring the Social Foundations of Learning Through Neuroscience, Technology, and Education

Patricia Kuhl, Director, LIFE Center (Learning in Informal and Formal Environments), University of Washington

Multi-disciplinary collaborative work in neuroscience, technology, and education is leading toward transformations in both the science and the practice of learning. Neuroscience studies indicate that humans are biologically prepared to learn socially from other people and that the social brain "gates" human learning across the life span. Results from totally different teams show that robots and gaming technologies are also more effective when the machines are programmed to interact "socially" with learners—to respond contingently, to follow a learner's movements and especially what the learner is focusing on, and to react to the learner's behaviour. Studies of learning in both informal and formal educational settings show that when learning is interactive—between people, or between a person and a machine—enhancements in learning occur when environmental settings mimic social interaction. This "social" conclusion extends to the broader idea that learning is embedded in the socio-cultural context in which it occurs. These principles about learning hold across domains (language, cognition, STEM). Understanding how humans' "social brains" affect learning is transforming basic theory as well as educational practice.

Examining Cultural Stereotypes, Child Development, and STEM Learning: The Science of Learning and its Translation to Education

Andrew Meltzoff, Co-Director, LIFE Center, University of Washington

New studies on STEM learning combine experimental science with educational theory and practice. The initial step investigates the mechanisms—biological, cultural, and psychological—that give rise to American children falling behind in STEM disciplines. Studies show that cultural stereotypes have a deep influence on children's performance regarding math. As early as 2nd grade, American children have acquired the stereotype that "girls don't do math" and this begins to influence their self-concepts. These findings have important implications for children's educational interests, success, and aspirations. Specifically, these results show the math–gender stereotype develops *prior* to ages at which gender-based differences in math achievement emerge. Based on these results, parental and educational practices aimed at enhancing girls' identification with math should occur as early as elementary school in the United States. Not all cultures share the American stereotypes regarding math. Cross-cultural studies are now underway in Singapore because it provides an interesting test-bed for theory and practice: In the USA high-school boys

outperform girls on many standardized math tests, but in Singapore it is the reverse—girls outperform the boys. The research investigates Singaporean stereotypes about math and whether they differ from those in the USA, and how children's self-concepts, math achievement, and cultural stereotypes are intertwined. This research illustrates the value of interdisciplinary work in the science of learning that spans from basic science to translational issues.

Media Use, Face-to-Face Communication, Media Multitasking and Social Wellness among 8-12 Year Old Girls

Roy Pea, Co-Director, LIFE Center, Stanford University

Media multitasking is a defining feature of the emerging social media environment. The 2010 *Generation M2* Kaiser report revealed young people consume media 7.5 hrs a day, yet pack 10.75 hrs of media content into those hours. As attention is the scarcest resource in the Attention Economy, and instrumental to learning, memory, and social relationships, we must deepen our attention to how media multitasking is shaping youth development. An online survey of 3,464 North American girls ages 8-12 examines the relationships between social well-being and young girls' media use — including video, videogames, music listening, reading/homework, emailing/posting on social media sites, texting/instant messaging, and talking on phones/video chat — and face-to-face communication. This study introduces both a more granular measure of media multitasking and a new comparative measure of media use vs. time spent in face-to-face communication. Regression analyses indicated that negative social wellbeing is positively associated with levels of uses of media that are centrally about interpersonal interaction (e.g., phone, online communication) as well as uses of media that are not (e.g., video, music, and reading). Video use is particularly strongly associated with negative social well-being indicators. Media multitasking is also associated with negative social indicators. Conversely, face-to-face communication is strongly associated with positive social wellbeing. Cell phone ownership and having a television or computer in one's room has little direct association with children's socio-emotional wellbeing. We hypothesize possible causes for these relationships, call for causal research designs, and outline possible implications of such findings for younger adolescent social wellbeing.

Transformational Model of Translational Research that Leverages Educational Technology for Fast Data-Discovery Feedback Loops

John Stamper, Technical Director, DataShop (LearnLab-Pittsburgh Science of Learning Center), Carnegie Mellon University

A key motivation for the importance of data-driven educational design and continual improvement is the recognition that much of school learning is performed by brain processes outside of explicit conscious awareness. The intuitions of instructors and developers are biased by explicit cognition — they experience "expert blind spot." New research is leading to more and better methods of seeing student thinking as it really is and using this information to better design learning experiences that adapt to students needs, capabilities, and interests. These principles led to the development of "Cognitive Tutors" and "Teachable Agents" to teach science. The results are motivating an emerging cyberinfrastructure or e-science of learning that involves educational technology, machine learning-based data mining and knowledge discovery, and vast on-line experiments in formal and informal learning settings.

From Laboratory to Classroom and Back

David Uttal, Spatial Intelligence and Learning Center (SILC), University of Chicago

CogSketch is a sketch understanding system being developed by the Spatial Intelligence and Learning Center. It uses human-like models of spatial and analogical reasoning to understand what people draw, and can do as well as people on some tests. Two synergistic goals drive this project: CogSketch is being developed both as a cognitive science research instrument and as an educational software platform. Our cognitive simulation and laboratory work provides models and insights that are used to improve our sketch-based educational software. Our experiences with students and classes, in turn, raise new issues that help drive our basic research agenda. This talk focuses on the two types of sketch-based educational software we are developing. *Sketch worksheets* are intended to help students learn spatial configurations and terminology in a variety of domains. *Design Coach* is being developed to help engineering students learn to communicate better via sketching during design. Experiments with students and classes, both completed and planned, are outlined, along with some of the issues that we are now investigating as a consequence.

Educational Neuroscience: Using Cognitive and Brain Science to Enhance our Understanding of Learning and Achievement in Math

Susan Levine, SILC Center, University of Chicago

Children show marked individual differences in their mathematical knowledge by the start of kindergarten, and these early differences predict their long-term mathematical achievement. I will present evidence that these early individual variations are related to wide variations in the early inputs children receive at home about number as well as spatial relations. But understanding individual differences in math proficiency requires more than knowledge about how they learn in content areas. Rather, social and emotional factors (e.g., students' fears and stereotypes about math) also impact their math learning and achievement. I will present work showing that teachers' knowledge and anxieties about concepts central to math (e.g., spatial reasoning, mental transformation, calculation) impact students' beliefs about their success in math and the growth of their math knowledge across the school year. Implications for education and assessment, as well as how neuroscience can inform our understanding of the interplay of emotion and cognitive control in academic settings, will be discussed.

Increasing Spatial Learning in Formal and Informal Settings

Nora Newcombe, Director, SILC Center, Temple University

There is evidence that spatial learning is critical to success in science, technology, engineering and mathematics (STEM) fields. This talk will highlight recent advances, from both observational and experimental research, concerning how to enhance such learning in the early years, to provide a firm foundation for STEM instruction. Some of the techniques involve structuring the input to children (e.g., use of adult spatial language, alignment of examples to enhance structured comparison, provision of atypical as well as typical instances of shape concepts) and other techniques involve affecting children more directly (e.g., encouraging gesture as children discuss dynamic spatial transformation). Many of the findings can be used in both formal and informal settings.

Creating Better Learners by Driving Neuroplasticity

Andrea Chiba, Director, Temporal Dynamics of Learning Center (TDLC), University of California at San Diego

All academic learning occurs through the obligatory plastic changes of the brain. Thus, discovering methods to behaviorally drive those plastic changes in ways that give the learner a neural advantage for academic success is becoming a realistic goal. There is extensive work in neuroplasticity and its role in education, particularly work on ameliorating the impairment of auditory temporal processing in children with dyslexia, which shows that a training regime that optimizes neuroplastic changes essential for rapid auditory processing can facilitate phonological perception and ameliorate dyslexia in these children. The idea that many academic skills rely on the trajectory of brain development and the fitness of various properties of the brain, alongside the notion that these plastic changes in the brain can be behaviorally driven or facilitated has led to a number of discoveries and new research directions: 1) how fiber tract development is modulated by exposure to a computerized math tutor system (ALEKS); 2) the Gamelan project is investigating how temporal processing and attentional processes may be influenced by intensive training in Gamelan, a Balinese musical form that places a high degree of emphasis on high-speed synchronicity between players; 3) a neurogenesis project which demonstrates how encouraging the birth of neurons in the dentate gyrus of the hippocampus through behavioral enrichment in rodents allows the predictions of computational models to be tested.

Diversity in Learning: Teaching Practices and Educational Policies that Impact Students' Visual Learning

Laura Ann Pettito, Science Director, Visual Language and Visual Learning Center (VL2), Gallaudet University

21st Century learners are highly diverse, and studies examine how learning differs across individuals is increasing in importance. Drawing from research spanning from neuroimaging to the classroom, teaching practices and educational policies have been identified that can positively impact students' (1) visual processing and visual learning, (2) reading acquisition, and promote (3) lifelong language processing and reading advantages with early bilingual language exposure. First, we show how early visual social interactions change the brain's visual perceptual systems in ways that teachers can harness to promote advantaged visual learning in all students. Second, like the young hearing reader who relies heavily on sound cues (phonology) as an intermediary bridge when accessing meaning from print in early reading acquisition, young deaf readers exposed to sign language use an intermediary bridge of visual hand and finger spelling units (analogous to a "visual" phonology) when accessing meaning from print in early text reading. Teachers' use of such visual phonological units may provide a powerful teaching aid to the acquisition of print reading in deaf and hearing impaired children. Third, we will discuss evidence showing that the age of a child's first bilingual language exposure is a predictor (a new tool for teachers) of the child's likely developmental course of bilingual language acquisition and reading mastery. Armed with such knowledge, teachers of children with Late-Bilingual language exposure can design better, and more targeted, remediation strategies to ensure bilingual language and reading success. Finally, we will discuss surprising evidence showing that Early-Bilingual language exposure and schooling provides young children with powerful language and reading processing advantages, as compared with their monolingual peers—so much so that early bilingual language schooling can even ameliorate the well-known deleterious impact of social economic variation on literacy.