NEUROSCIENCE FOUNDATIONS IN TEACHER PROFESSIONAL DEVELOPMENT DELIVERS UNEXPECTED ADAPTIVE EXPERTISE OUTCOMES

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Abstract

This paper reports findings from a National Institutes of Health longitudinal study that introduced fundamentals of neuroscience to middle school teachers. Results offer immediate implications for how teachers teach and how adolescent students learn. In this timely study, we deliver tangible findings to a growing field that connects neuroscience with teaching and learning. Theories in action are described and studies for future research are suggested. The main question focused on measuring learning outcomes when teachers increased their knowledge of how brains work and how children learn. Can one gain insights into how to teach from the knowledge that neurons communicate with action potential firings along axons? Is an increase in knowledge about axons, dendrites and how neurons communicate beneficial for teachers’ practice and how can we measure this? An interdisciplinary team implemented a learning sciences pedagogical model, which translated research in neuroscience into practice and strategies for incumbent middle school teachers (N=125) in a regional (Puget Sound) Educational Service District. Cumulative evidence is described in a mixed methods model that includes quantitative data and ethnographic descriptive data. Findings illuminate tangible outcomes for teachers who received (i) a prescribed neuroscience course, and (ii) a follow-on tech-enabled PLC (Professional Learning Community) experience. Three learning outcomes are reported here—findings, which appear to move the needle toward adaptive expertise for middle school teachers in adolescent classroom settings: (i) all teachers gained relevant information relating to human anatomy and brain for adolescent learning, (ii) all teachers used brain-centric pedagogic models that ‘made visible’ student attitudes in areas like ‘stress’ and ‘mindset’ in adolescent learning, and (iii) a knowledge of neuroscience principles impelled teachers to define an ‘edge’ to their teaching capacity with regard to classroom methodologies and theories—an edge that we describe as ‘adaptive’ expertise. Future studies are suggested that focus on ideas for attenuating these particular outcomes in more in-depth studies that seek to increase teacher capacity and neuroscience footprint in classrooms beyond middle school.

Keywords: neuroscience, adaptive expertise, pedagogy, learning models.

1 INTRODUCTION

Twenty-first century schools are different. It’s not just technology—smart boards, laptops, iPads, cell phones, cloud services, collaborative practices, and more. The world is different, students are different in a connected, distracting information age, and teachers and parents recognize the need to be different as a direct consequence to this historical change.[1] Teachers are often reminded that they are tasked with preparing students for jobs that have not yet been created, technologies that have not yet been invented, and problems that we don’t know will arise.[2] Qualities that are recognized as twenty-first century requirements in youth are not measured by standardized tests that tend to drive educational marketplace and parental choice. These include skills and qualities like persistence, curiosity, enthusiasm, courage, leadership, creativity, growth-mindset, civic-mindedness, resourcefulness, self-regulation, sense of wonder, big-picture thinking, compassion, reliability, motivation, humor, empathy, sense of beauty, humility, and resilience.[3] Until recently, many schools were modeled on systems that were grounded in conveyor-belt (factory) thinking.[4-6] Neuroscience, although recognized as an important component of mind, memory, and cognition [7, 8], remained peripheral to school content delivery systems and indeed was rarely an integral part of teacher courses in professional preparation.[9] Although this paper focuses on connecting neuroscience with
teaching and learning, the findings described herein are evidential outcomes defined by insights from cognitive psychology. Strategically, the focus and intentionality engages questions about teacher’s capacity to achieve learning outcomes when knowledge of neuroscience underscores practice in daily activities in classrooms. However, children were not inserted into fMRI machines; no scanning of brain activity is reported and no evidence of changes in neural structures is either explained or mapped directly with imaging techniques.

**How Do I Learn (HDIL)** was a project under the auspices of the National Institutes of Health Blueprint for Neuroscience Research program that sought to increase knowledge of neuroscience in middle schools for teachers, students, and for parents. As a part of a five-year grant, HDIL personnel created courses, curricula and institutes that delivered information to teachers, administrators, coaches and principals in educational service districts serving the locale within the geographic milieu of the university where the HDIL team worked. In addition, they provided workshops for parents so that they too had immediate access to the same information that ‘made visible’ the specific knowledge necessary to understand the developmental process of a typical teenager’s brain. Finally, as active participants in face-to-face summer institutes that focused on the neuroscience of learning, teacher teams experienced pedagogical models and related materials and were required to create a dynamic keystone project that illustrated their understanding of how brains work and how humans learn. This paper will describe the HDIL program, including processes, practices, and data for the duration of the five years that the program was in operation. Findings will be presented and discussion relating to these findings will illuminate ideas that emerged as a result of the work accomplished and the dissemination of a meaningful corpus of information. Next steps will be suggested in the changing field of mind, brain, and education.

While it could be claimed that more information was discovered about the human brain in the past 25 years than in the previous 250 years, unfortunately, this information rarely percolates with any great depth into specific spaces that are highly dependent on knowledge about brain function for their daily thrust—teachers, learners, trainers, coaches, and parents. Consequently, ideas about plasticity, intelligence, mindset, and potential were uppermost in the minds of leaders and participants in the HDIL Summer Institutes, given that these topics engage so deeply with learning and the brain.[10] For instance, emerging research [11] concerning a deep understanding of the impact of white matter (myelin) and its involvement for normal cognitive function, learning and IQ was an underlying theme in HDIL summer institutes. Emerging knowledge about brain can have profound implications for teachers and learning sciences researchers since it serves to “illuminate an under-appreciated role of myelin in information processing and learning.” (p. 361) One of the key capacities of HDIL was intentional ability to locate and translate new research that has implications for the classroom by devising practices and processes that are tangible for teachers and parents, and can offer help to teenagers by growing their awareness of brain models.

The HDIL study coincided with a focus on learning and neuroscience associated with political insights into advanced tools for classroom improvements. In the closing years of the 20th century a real effort to engage in brain awareness permeated learning theory during the ‘Decade of the Brain’ where research investment was expected to bring advancement to areas of cognition and learning.[12-14] This new knowledge was coupled with a visceral drive to understand both conceptually and practically how the emergent field of neuroscience (aided as it was by persistent developments in technological advances in imaging techniques) could deliver systems and methods to classroom teachers and, also, advance learning theory.[15] In spite of advances in biological and anatomical knowledge, and in spite of increased spending on research and inquiry, application of neuro-scientific principles ran into many roadblocks with regard efforts to engage in practices that might improve teaching and learning. Caution was the watchword of the day. Scientists in fields long associated with pedagogy and psychology urged guarded acceptance of new ideas that included neuroscience in the classroom. For instance, the educational psychologist John Bruer (1997) affirmed that neuroscience and educational practice was undoubtedly a bridge too far. He asserted that “…educational applications of brain science may come eventually, but as of now neuroscience has little to offer teachers in terms of informing classroom practice.”[16] With the passage of time however, and the accumulation of a greater body of knowledge, both learning scientists and neuroscientists recognized that innovative designs could allow this promising material to study the effects of variables of interest (e.g., context) in education. For instance, Varma (2008) concluded that a powerful way to improve education was to

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1 Dr. Fields’ seminal work on white matter, which pointed out that myelination continues for decades in the human brain. His work affirmed that myelination is modifiable by experience, and affects information processing by regulating the velocity and synchrony of impulse conduction between distant cortical regions.
design and implement new learning contexts and interactions and in particular using FMRI experiments “to measure differences in brain activity after students have experienced different contexts.”[17, 18]

2 THEORETICAL FRAMEWORK

In this research project, we drew on the philosophic literature that describes adaptive expertise (AE) and the critical understandings that underpin this mode of thinking with particular reference to teaching and learning. HDIL theorized that teachers’ willingness and capacity to become ‘adaptive experts’ was essential for the success of implementing neuroscience pedagogies in the classroom.[19] In the expertise literature, Hatano & Inagaki[20] have identified two courses in expertise—routine versus adaptive—that define mindset and application. According to the AE school of thought, expertise is expressed in one of two dimensions decidedly orthogonal to one another; (i) processes that accelerate efficiency through well practiced routines, and (ii) processes that lead to growth and change through innovation and mindset.[21] Adaptive expertise has been further codified in educational settings[19, 22] as existential qualities of personal development that are as much emotion, resilience, and innovation as grit[23], and mindset.[24] Teachers, who are adaptive in their expertise, employ unique representations and methods to solve problems,[25] seek out opportunities for new learning in their practice,[26] successfully monitor their understanding of situations in a metacognitive manner,[27] and conceive of knowledge as dynamic rather than static.[28] We operationalized the measurement of adaptive expertise by defining categories and scoring output of EAs’ keystone deliverables that accounted for a deep understanding of how the brain works and how children learn. For instance, an EA who described a process for introducing and measuring the effectiveness of growth mindset in classroom activities (learners would develop positive self-esteem, and techniques for self-regulation) was scored on a scale of 1 – 10. Meanwhile an EA who focused his/her work on Skinnerian rewards or punishments (reducing a child’s recess time so that he/she could finish a Math homework) was scored on a similar scale only negative; -1 to -10. Methodology

HDIL team used a mixed method to make sense of the findings of this research program. Learning environments are invariably unbounded, non-linear, and messy. In classroom environments that are engaging and fun, outcomes are rarely attributable to causation principles in a simplistic manner, and it is often a stretch to assume that research data collected in these settings will converge on an indisputable ‘truth’ or panacea. Nevertheless, outcomes can be attributable to stimuli, interventions, and/or changes in methodologies/practices when evidence is demonstrable from situational angles, which point to causative impetus. A mixed method approach offers intriguing windows into what is really going on in ‘active’ learning settings. This method is used increasingly in social sciences because its nuances are more keenly aligned with the divergent issues that crop up in disorderly and often chaotic systems. Philosophically, mixed research methodologies make use of the pragmatic approach and system of thinking. Its logic of inquiry includes the use of induction (discovery of patterns), deduction (testing of theories and hypotheses), and abduction (uncovering and relying on the best of a set of explanations for understanding one’s results).[29] To this end, triangulation events from a mixed method approach, provides breadth of perspective that illuminate issues we are interested in (for instance, could we assign functional adaptive expertise attributes to teachers who were intentional about metacognitive processes and growth mindset techniques). We were confident that variation in data collection associated with mixed method exposition would lead to measurable validity.[30] Finally, a mixed methods approach ensures that pre-existing assumptions articulated by the research team would be less likely, since this method allowed us to integrate data from several sources in order to clarify and/or better understand the problem space under investigation.

A team at the University of Washington’s School of Nursing collaborated with learning scientists at the university of Washington College of Education, LIFE Center (Learning in Informal and Formal Environments to deliver the HDIL program over a five-year period. The team was augmented by members of the University of Washington Professional and Continuing Education department and in close cooperation with the Puget Sound Educational Service District. Finally, expertise was culled from various other departments from within the colleges of psychology, health and sciences and neurosciences at the University of Washington and other third level institutions (e.g., expertise on sleep from a neuroscientist at Williams College, Massachusetts and expertise on stress from the Laboratory of Neuro-Endocrinology at Rockefeller University, New York). A central tenet of the program was to engage middle school teachers and their students (and to a lesser extent parents and the community), in a scientific program of neuroscience education. The objective was to increase middle school teachers’ understanding about ‘how students learn’ as well as dispel common myths
about brain and learning. Teachers were invited to attend a summer institute that presented current knowledge from neuroscience research relevant to brain and how children learn. HDIL intervention consisted of a two-part immersive and interactive program that engaged participant teachers in a one-week summer institute and follow-on professional learning community (PLC) program.

2.1 Subjects and Recruitment

Subjects were predominately middle school teachers serving the Puget Sound Educational Service District, Washington. Content expertise included middle school science, mathematics, English Language Arts, Library as well as Physical Education, counselors and several administrators. Participants were recruited through the University outreach emails and through partner organizations in the grant (e.g., Puget Sound Educational Service District, and University of Washington College of Education). A sample recruitment letter is attached in Appendix 3. Applications were restricted to teams (usually 3 to 6 individuals) that contained at least one middle school science teacher. In addition, preference was given to teams who represented Title 1 schools (high percentages of children from low-income families). An honorarium ($500) was awarded to successful candidates who fulfilled the academic requirements and attended/contributed to Summer Institute activities and deliverables. Academic credit and clock-hours were supplied to participant teachers who wished to advance their careers in this arena. Each participant was issued a schedule upon arrival at the orientation on day one (see appendix 1: Sample Schedule for EA Summer Institute) that outlined content, events and speakers during the week of the Summer Institute. All participants provided written informed consent, which was part of the recruitment and application process. No data was collected from any students for this study.

2.1.1 Instruments

Several instruments were drawn up to collect data. A thorough grounding in the biology and functional details of neuroscience was a requisite step to deep understanding of adolescent learning. To that end instruments were designed to ascertain the level of knowledge and changes that occurred as a result of the HDIL immersion.

- A Pre and Post instrument was produced in order to ascertain the level of neuroscience knowledge that on-the-job teachers were acknowledging as a result of immersion in the summer institute (see appendix 2: HDIL Summer Institute Pre-Survey 2015). The post survey is identical to the pre survey. In the survey, participants were asked to state their level of knowledge with regard to topics and content information that derived from neuroscience pertaining to teaching and learning.

- In addition, a similar Pre and Post Survey instrument was introduced in order to ascertain the impact of establishing an ongoing professional learning community (PLC) as a follow-on learning tool to advance the work of the project. The PLC that continued the work begun in the Summer Institute and focused on delivering similar experiences and materials for the remainder of the school year.

The goals of the PLCs were to increase knowledge of neuroscience research with a focus on applications for classroom teaching. The PLCs featured presentations from experts, a book study (Wilson & Conyers: *Five Big Ideas for Effective Teaching*), presentations from teams, and on-going discussion.

2.1.2 Pedagogical Model

Facilitators used a brain-centric pedagogical model called the Challenge Cycle during the PLCs to deepen participant awareness of learning models and engagement. To this end, a pedagogical model, (see: Fig. 1 The Challenge Cycle) was the central descriptive process for implementing both the neuroscientific content materials and the method for engaging the participants in their keystone project, which was a deliverable at the end of the summer institute and continued throughout the school year in the PLC interaction.
A pivotal aspect of this methodology centered on making visible a metacognitive moment that highlighted a participant’s shift in thinking (learning in action) and was associated with neural substrates that involved neural plasticity, cognitive rehearsal, and mental models that demonstrated synaptic connections, myelination, and learning with deep understanding. As part of the philosophic underpinnings of Adaptive Expertise, teachers were encouraged to become metacognitive about their own work and to reflexively witness a shift in their own thinking within the cohort.

2.1.3 Data

Data were collected via video, audio, observations, survey instruments and interviews. The data, being both quantitative and qualitative was treated differently as needed. Quantitative data derived from survey instruments were tallied and analyzed. Videos were transcribed and vetted for accuracy and clarity against the original tapes. Transcription protocols[31] were used to account for tone, humor, pace, and rhythm in turn-taking and other interactions of participants. Discourse analysis was used to unpack discussion topics and routine interactions in order to make meaning in relation to discovery and exposition. Categories and codes were deduced from the corpus of data that was produced. An on-demand real-time collaborative software package (Dedoose, 2016) was used to facilitate excerpting, coding, and analysis of the qualitative data and these data integration with demographic and other quantitative data to unearth hidden patterns and relationships.

3 RESULTS

Findings for HDIL summer institutes and follow-up professional learning community (PLC) data are described here. This one-year snapshot (end of a five-year cycle) summarizes implementation challenges and successes, expected and unforeseen impacts, and implicit and explicit teacher impact. Data, which were captured in pre and post survey instruments, were analyzed using data analysis tools that align with the data (quantitative or qualitative). Results describe impact of attending HDIL summer institutes and applying new information in school settings afterwards. We focused on participant gains in neuroscience knowledge, and the impact of the HDIL program on teaching practices.

3.1 Neuroscience Knowledge

Pre and post scores confirm that all participants gained with regard to naming, identifying, and understanding the function of regions of the Brain that relates to learning. In the following graphic, (Fig. 2. HDIL SI 2015 Gains in Neuroscience Knowledge) participants demonstrated a gain in knowledge about, and an understanding of, parts of the brain, and their functions. The Y-axis is calibrated to show knowledge levels from 0 to 100 (e.g., I know nothing about the hippocampus = 0, to the hippocampus is in both hemispheres and is associated with creating memory, processing and storing information = 100).
Survey responses from participants show clear evidence that teachers gained knowledge about how neuroscience implicates learning and teaching. Areas of focus included the following: Plasticity, Intelligence, Learning, Stress, and Beliefs. Figure 3. HDIL SI 2015 Gains in Application Neuroscience Knowledge demonstrates the change from pre to post for participants of the Summer Institute in 2015.

Fig. 4. HDIL SI 2015 Gains in three areas related to Application of Neuroscience Principles in the Classroom: (i) Stress Reduction; (ii) How Neurons Communicate; (iii) Reading Research
Fig. 5. HDIL SI Codes Report highlights how teachers expressed ideas and espoused practices that connect with constructs in Adaptive Expertise. While teachers (see arrows) were heavily drawn to constructs like Neuroscience Structures (score = ~60), and the importance of Exercise for brain-centric learning (score = ~45), the largest (by a considerable margin) impact for teachers emerged as change to their processes and practices – a shift to Adaptive Experts (score = ~130).

Evidence from recorded meetings, back-chat exchanges, and report-out presentations of participant keystone projects verified that teachers who took part in the Summer institutes and followed through with PLC activities manifested an edge to their expertise that was in alignment with protocols that are evidence for constructs of Adaptive Expertise.[19]

3.1.1 Adaptive Expertise

Ostensibly, prescriptive teaching in a traditional methodology is exemplified in Fig. 6 on the lower left hand sector of the learning cube. It is characterized as Routine, Fixed and Behaviourist. Teachers who participated in the HDIL program were able to visualize their being in this space and knew lots of other teachers (and parents) in this space. On the other hand, teachers who completed the HDIL program were able to witness their own progression to a more Adaptive, Growth and Cognitivist space (upper right reaches of the learning cube), where they associated knowledge of neuroscience with their everyday classroom teaching and learning activities.

4 CONCLUSION

This paper described a program in which teachers acquired theoretical and practical knowledge relating to neuroscience with respect to how the brain works and how children learn. Two questions
were of interest: would this kind of experience and knowledge have meaningful implications in the classroom for students and would teachers adopt new methods and practices as a result? Findings verify that teachers gained insights into neuroscience and were able to convert this knowledge into practices in the classroom to bring about positive change. Teachers describe many instances where they attained ignition in their practice because methods that used to work intuitively connected with evidence from neuroscience, and methods, which they experienced as not working, were equally associated with evidence that explained why they could never work.

There were several items that color this research. First, assignment was not random and we do not have a true control group; participants in the advanced group (which is the closest thing we have to a comparison group) are self-selected rather than randomly assigned.

The most important take away from this research program focuses on the positive impact that neuroscience knowledge has for teaching and learning. There is an increasing body of knowledge about neuroscience and learning at universities even if it is spread out across several silo’d organizations/schools (e.g., nursing, medicine, psychology, education, biology and so on). We highlight in this research project that it can be successfully centralized through one program and passed on to teachers and parents through an immersive summer institute and a follow-on PLC. Lessons we learned included information about the design of such a project, Summer Institutes, online PLCs, organizing teachers in teams, using expert presenters effectively, integrating book study and discussions as interactive learning, and so on.

4.1 Next Steps

Clearly then, one of the next undertakings for educational researchers involved in this sphere of inquiry is to measure (with imaging devices), structural pathways and neural activations that result when teachers approach their work from a cognitive neuroscience perspective and framework.

Capacity building is clearly a next step in the execution of further gains in this emergent field—connecting neuroscience with teaching and learning. The need for brain-centric thinking in the classroom has been made more than visible by this study, and teachers who are imbued with knowledge, skills, and mindsets that translate into meaningful practices are testament to the transformative change that such a program can deliver.

ACKNOWLEDGEMENTS

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REFERENCES


APPENDIX 1: SUMMER INSTITUTE EA SCHEDULE

Sample Schedule for Education Associate Summer Institute (June 2015)

APPENDIX 2: SUMMER INSTITUTE PRE/POST SURVEY INSTRUMENT 2015

Welcome to the How Do I Learn Summer Institute! We are asking you to complete the following survey to help plan the activities, prepare the expert presenters, focus you on the topics of the Summer Institute activities, and evaluate the impact of this project. Please complete this survey by Monday, June 15, 2015.

Your responses on this survey serve as a baseline of what you know before participating in this project – much like a pre-assessment you would give your students prior to teaching a lesson or unit in your classroom. You are not expected to know the answers to some of the question on this survey and that is fine. We ask you to make your best guess and not use other resources to look up the answers. A post-survey at the end of the Summer Institute helps us assess changes in knowledge, attitudes and practices as we are required to do by our funder.

Your responses to these questions are voluntary and anonymous. Your comments may be included in a summary report, but in such a way that no one will be able to identify you. If you have any questions or concerns, please contact Bruce Cunningham, Director Evaluation and Research, Puget Sound Educational Service District at PSESD. Each of the questions below uses a slightly different format to ask what you know about a particular topic. For some questions you check one bubble, for other questions you check multiple boxes and for still other questions you are asked to write a brief response. Thank you for your time in completing this survey.
Question 1. Which parts or processes of the brain are still developing in adolescents and don’t become fully developed until individuals reach their mid-20’s? *(check one bubble for each item)*

<table>
<thead>
<tr>
<th>Still developing until the mid-20’s</th>
<th>Developed before the mid-20’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>The corpus callosum</td>
<td>O</td>
</tr>
<tr>
<td>The prefrontal cortex</td>
<td>O</td>
</tr>
<tr>
<td>The cerebellum</td>
<td>O</td>
</tr>
<tr>
<td>The medulla</td>
<td>O</td>
</tr>
<tr>
<td>Myelination</td>
<td>O</td>
</tr>
</tbody>
</table>

Question 2. Which of these brain changes occur as learning takes place? *(check one bubble for each item)*

<table>
<thead>
<tr>
<th>This occurs with learning</th>
<th>This does not occur with learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in dendritic spines</td>
<td>O</td>
</tr>
<tr>
<td>Thickening of myelin</td>
<td>O</td>
</tr>
<tr>
<td>Lengthening of axons</td>
<td>O</td>
</tr>
<tr>
<td>Remodeling of neuronal pathways</td>
<td>O</td>
</tr>
</tbody>
</table>

Question 3. What is the effect of stress on memory? *(check one)*

- O Stress may improve memory
- O Stress may impair memory
- O Stress may improve or impair memory
- O Stress has no effect on memory
Question 4. The two hemispheres of the cortex are connected by . . . (check one)

- Glial cells of the corpus callosum
- Myelinated axons of the corpus callosum
- Blood vessels only

Question 5. The medial temporal lobe contains structures important for . . . (check one)

- Learning and memory
- Language
- Some aspects of emotional behavior
- All of the above

Question 6. Which of the following are parts of the body’s stress response systems? (Check one bubble for each item)

<table>
<thead>
<tr>
<th>Part of the stress response system</th>
<th>Not part of the stress response system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenal gland</td>
<td>O</td>
</tr>
<tr>
<td>Hippocampus</td>
<td>O</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>O</td>
</tr>
<tr>
<td>Pancreas</td>
<td>O</td>
</tr>
<tr>
<td>Pituitary gland</td>
<td>O</td>
</tr>
</tbody>
</table>

Question 7. Name or briefly describe one technique that is recommended to reduce stress.
Question 8. Name or briefly describe a second technique that is recommended to reduce stress.

Question 9. Name or briefly describe a third technique that is recommended to reduce stress.

Question 10. Identify the parts of the neuron in this diagram. (Check one bubble for each item)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Axon</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Dendrites</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Node of Ranvier</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Cell body</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Myelin sheath</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Axon terminals</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
Question 11. Identify the functions of the parts of a neuron in this diagram.  
(Check one bubble for each item)

![Diagram of a neuron with numbered parts](image)

2 4 5 7
Takes information away from the cell body O O O O
Takes information to the cell body O O O O
Functions as insulation O O O O
Releases neurotransmitters O O O O

Question 12. Write a brief response to this prompt: What is the stereotyped form of the electrical messages ("bits" of information) in our nervous system? How do they travel long distances and from cell to cell?

Question 13. When teaching a new lesson or curriculum unit, to what degree do you incorporate each of the following steps? (Check one bubble for each statement)

<table>
<thead>
<tr>
<th>Step</th>
<th>Not at all important</th>
<th>Not important</th>
<th>I’m not sure</th>
<th>Important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>I introduce lessons with challenging or intriguing questions</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>I have students generate ideas or make predictions before teaching the lesson</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>I expose my students to multiple perspectives on a topic</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>I have students reflect on what they are learning</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>I have students share and articulate their thoughts with other students</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>I have students share their new learnings publicly in some way</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>
Question 14. To what degree do you agree or disagree with the following statements about how our brains work? *(check one bubble for each statement)*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>I'm not sure</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The brain is plastic and capable of change throughout our lives</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Intelligence is a fixed trait that does not change throughout our lives</td>
<td>O</td>
<td>O</td>
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<td>Learning involves physical changes in the brain</td>
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<td>Learning is not influenced by factors such as stress, sleep, and exercise</td>
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<td>Our attitudes and beliefs about how the brain work are essential for learning</td>
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<td>We can learn and understand without knowing how the brain works</td>
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Question 15. Name one factor you consider to be highly important in determining the quality of information on a website for information about neuroscience.
APPENDIX 3: SUMMER INSTITUTE RECRUITMENT LETTER 2015

How Do I Learn? Summer Institute
Focus: Stress and Its Impact on Learning

The How Do I Learn (HDIL) week-long intensive summer institute connects teaching and learning with neuroscience. The institute has two purposes: to increase participants’ understanding of the adolescent brain; and to assist them in aligning their teaching practices with this new knowledge. We are currently accepting applications from elementary, middle and high school teams for this How Do I Learn summer institute. The topic for this year’s institute will be: Stress and Its Impact on Learning.

Details:
Team Composition: Teams can consist of three to six members. All teams must contain one middle school science teacher. Preference will be given to teacher teams who come from Title I schools and include at least one administrator.

Dates: June 20 – June 24, 2016. From Monday through Friday you and your team will be at the University of Washington campus. All summer institute participants are required to attend a welcome dinner on Monday evening, June 20, from 5:30 – 6:30 pm at the Principal Investigator’s home. This dinner will serve as your orientation to the program.

Requirements of the Institute: To successfully complete the institute, you must attend and participate in all summer institute sessions (including the welcome dinner), submit an individual action plan; provide reflections on your individual lesson plan as well as your team members’ action plans; and participate in evaluation activities related to the HDIL program.

Honorarium: $500 will be paid to participants who meet all the requirements of the How Do I Learn summer institute. Teachers will use their honorarium to pay for their own expenses including credits, food, lodging and travel.

Credits: Four (4) academic credits. The fee for credits is approximately $250, or you can receive up to 40 clock hours with a registration fee of $46.

Deadline: The application deadline is April 1, 2016.

How to apply: The application is online. Each team member will need to submit an individual application and reference the names of their team members. The program will accept between 4-6 teams this year and is limited to 25 participants. Visit our website for application details: https://sites.google.com/a/uw.edu/howdoilearn/

Questions: For questions about the Summer Institute, please contact Jenny Williamson: jwill@uw.edu or Liahna Fullero-Noon: janw@PCE.UW.EDU

“How Do I Learn” (grant 1R25DA033002-05) is funded by the NIH Blueprint for Neuroscience Research and administered by the National Institute on Drug Abuse (NIDA), part of the National Institutes of Health.
APPENDIX 4 NEED FOR CAPACITY BUILDING TO INTEGRATE NEUROSCIENCE INTO FACULTY PRACTICE

The following description is taken from a HDIL EA who, after a fourth session in the program, still struggles to understand the constraints that prevent teachers from being amazingly successful.

The thing that has stuck with me throughout this year is the need to do something more about spreading this information (neuroscience for teachers) to other colleagues. In our school this year (and we are not untypical), we had a 50% staff turn over, we had 2 teachers leave in the middle of the school year, and we have had a lot of conflict between kids and teachers… because teachers don’t know a lot of this neuroscience solution. I feel like so much of the time conflicts we have with the kids, not just behavior conflicts, but conflicts about work and conflicts about work ethic and getting work turned-in, or work finished, have so much more to do with the teacher than they do with the student. Our teachers were not offering solutions. We need to know how to take away a lot of the things that kids sabotage themselves with… and the stumbling blocks they put in their own way… and the things that circumstances puts in their way as well. Its very frustrating… the idea that would let the lack of a pencil stop a kid from participating in your lesson. Why would you do that? Why would you use the pencil as the lesson? The pencil is not the lesson! Why would you let the lack of the pencil stand in the way? But there are teachers who do that. Why would you let the lack of a piece of paper stand in the way? You know, that's not what you are trying to teach. And why would you let the kids’ inability to keep track of a laptop, although that is a little bit bigger than a pencil or a piece of paper, take that away? You know, when you let a pencil, piece of paper or a laptop stand in the way and you make that… the lesson, then they are not learning what you are really supposed to be teaching. And we still have a lot of teachers who think that is the lesson… bringing a pencil to class. They are wasting a lot of time fighting these battles they can’t win because they are unwinnable. If we can really listen to what's going on in other classrooms… and think about the adults in those classrooms… and their leadership and what they’re expectations are in those classrooms… and what battles they are picking in those classrooms and to think how I… what could I do to give them this information that would make it easier for them… to be the leaders in those classrooms? I mean … we can know all this information about kids and how they learn, but if there is nobody there to implement it… if the person leading the classroom doesn’t know how to implement … then it doesn't matter that we know it. We need to be able to inform the teachers in those classrooms about what we know that they need to know. It’s good kids know too, its great kids know about brain; it makes their lives easier. But the teachers who are leading those groups need to be as knowledgeable about those things as the kids are. And if we’re focusing just on educating the kids in our respective classrooms and not the other teachers that kids come into contact with daily, then we are only doing half the job. I mean it’s… we need to have the other adults that are with us in this also know these things. And… it’s hard to make that happen, I don’t have an answer for that.

- HDIL EA ASI 2015 (10+ years experience 4th time in HDIL)
APPENDIX 5 INSTRUCTIONAL MODEL THAT UNDERPINNED HDIL SUMMER INSTITUTE

Mosaic Learning Cycle: A Design-Based Implementation Research that Connects Neuroscience with Teaching and Learning

This proposal outlines a University of Washington-based collaborative research and implementation project, which seeks funding to “build out” and release a state-of-the-art design model for learning and teaching. This model emerged out of the first How Do I Learn (HDIL) Summer Institute, which was facilitated as part of the NIH-funded Blueprint for Neuroscience project designed to connect neuroscience with teaching and learning. In the HDIL project, learning scientists from the College of Education join the School of Nursing, Educational Outreach, and the Learning in Informal and Formal Environments (LIFE) learning center at the University of Washington plus the Puget Sound Educational Service District to bring neuroscientists and teachers together in the advancement of both their knowledge domains and science.

Objectives and Goals

Pedagogic model and instructional tool that was so instructive during the summer institute. This tool is used to support a pedagogical model that manages the delivery of content for teachers and students. It was central component of HDIL Institute where teachers and neuroscientists collaborated to advance learning in this field. A critical outcome became apparent in the form of this pedagogical model, which facilitates pedagogical innovation in classrooms for teaching and learning.

Rationale

While many cyber interfaces profess to be content providers for teaching and learning today, none are connected with evidence-based research rooted in the learning sciences: findings and evidence that foster principles of How People Learn and deep understanding. This Learning Cycle’s anchored architecture and philosophical framework describes a dynamic interface that engages learners’ generative and metacognitive agencies while promoting a ‘Preparation for Future Learning.’ This learning sciences model is designed for widespread school use for delivering content or curriculum. It is easily customizable for branding within and across communities for course delivery as needed.

Principles of Learning by Design

This curriculum is part of a body of work that had its initiation in a framework of ‘anchored instruction’ pioneered at the Cognition and Technology Group at Vanderbilt [3]. Many iterations of this platform have surfaced in various forms in the past number of years (including STAR Legacy, Jasper, and Challenge-based Learning) at various universities including Vanderbilt, and the University of Washington Learning Sciences group at LIFE [14, 32, 33] and University of Texas. The fundamental premise for this platform is based on a vision that technology and education can be powerful catalysts to promote learning; and that education can change lives, families, communities, and ultimately nations. Ideas for this model have been influenced by several major conferences sponsored by industry and the partnership for Twenty-First Century Skills that have attempted to focus attention on our changing world and the need to make changes in education in response to that. Developers of this program took advantage of several key publications from the National Academy of Science and National Academy of Education including How People Learn (2000), and How Students Learn (2004). Many of the ideas are also founded on models of learning that stem from emergent philosophic thinking like Adaptive Expertise (Hatano & Inagaki, 2000) and LIFE Center notions of Learning in Informal and Formal Environments. The LIFE Center (www.LIFE.com) is a National Science Foundation Science of Learning center that focuses on ideas of learning in both formal and informal environments.
Mosaic Learning Cycle:
This cycle is a challenge based learning system that focuses on investigating, explaining, and resolving meaningful problems. The formative aspect of this model is that it is simple; it is anchored on the premise that the Big Idea is a guiding principle for how the brain works and how learning is best accommodated.

The premise for the Mosaic Learning Cycle is that students learn when information is presented in a manner that (i) aligns with brain-centric design/thinking leading to cognition and deep understanding, (ii) fosters agency for the learner who takes control of his/her own learning, and (iii) accommodates a metacognitive process that enables the learner to understand and optimize how he/she learns. Future work will investigate and make visible the key components that are cognitively entrained when students are active in “Initial Thoughts” and “Revised Thoughts” segments of the iterative cycle.

Anatomy of the Mosaic Cycle
The Mosaic iterative challenge cycle comprises several interlocking modules that support principles of learning and teaching as follows:

The Challenge:
The challenge is usually presented as a scenario in a short video that helps focus one’s attention on the big issues to be solved. In this module learners will watch a short scenario where they will be asked to join a team of people who are trying to solve the challenge. Attention is triggered with novelty and details that connect the learners with the challenge. Focus and working memory are further engaged in the short time that it takes to write initial thoughts (usually 1 minute).

Initial Thoughts:
In this mosaic learners will have an opportunity to write their initial thoughts about how one might go about solving the challenge presented earlier. This helps make visible any preconceptions about the content. It is a safe space because only the individual student him/her self will see this information. It establishes a baseline—what I knew coming into the challenge. Overcoming the threat response by learning in and engaging with the challenge allows learner to generate new ideas and establish baseline of thinking. Predicting outcomes, generating ideas, and writing thoughts all insure the learner is in the prefrontal cortex while these activities are adhered to.

Multiple Perspectives/Resources:
After entering their initial thoughts learners proceed to the next Mosaic and explore several perspectives relative to the challenge. Here learners receive multiple perspectives from experts in the content area of the challenge. As students listen or watch each of the resources, they are encouraged to take notes to compare their thinking later. The purpose of these resources is to prompt a student’s thinking about issues and prepare them for productive discussion with others. Ideally, the material is presented in chunked easy to manage bites of information that are tailored to the challenge and are both entertaining and engaging to watch or read. Novelty, color, voice (think 6:00 o clock evening
newscast) and cognitive rehearsal assist the learner stay focused and on task during the content delivery instances.

**Reflect and Revised Thinking:**

After experiencing the resources, learners are then asked to reflect on their thinking by comparing what they know now with what they knew at the beginning (Initial Thoughts). To do this, they are asked to view the challenge again through the lens of a scaffolded exercise that includes three simple questions as follows: (i) What surprised you about the multiple perspectives and this challenge? (ii) What did you already know but now see in a new way? And (iii) what do you still need help with? Learners write their responses; they will be able to compare it to what was previously written and observe (in a metacognitive moment) any shift in thinking. Learners will find this comparison of their early and later thoughts very productive since it outlines (makes visible) for them how their thinking has shifted to incorporate new ideas. Next, in the second portion of this mosaic learners are asked to discuss their thoughts (what they wrote down in answer to the three questions just mentioned) in small groups to deepen and explore with others the relevance of the ideas and comments that emerged during the multiple perspectives. In this part of the challenge cycle, individuals are encouraged to work with their colleagues to understand how the ideas in the resources either fit or fail to fit with their own experiences. During the discussion with small group, individual learners are asked to assume a role—spokesperson, taskmaster, time-keeper, and scribe, as needed in preparation for the final report out. During this phase, learners move from being alone to being part of a cohort who have worked together and solved the challenge—consensus view in a safe learning environment. This removes fear-based barriers to generating new ideas and advocates for stepping outside comfort zones and taking risks in safe space.

**Report Out:**

When this process is completed, groups are asked to present to the larger group (use spokesperson) so that everyone's ideas can be heard, new ideas emerge and a sense of community is cemented. The mosaic learning cycle covers issues that are both thought-provoking and pertinent to the initial challenge. At the end of the learning cycle there is an opportunity to pull together ideas from each module and begin to craft an action plan. Ideally the plans they craft are helpful to solving the challenge and to each individual's learning process. This final mosaic of the learning cycle brings a unit, or a single class activity (at the teacher's discretion) to completion. The objective is to co-create a corpus of new information that helps children learn. Ultimately, it can be used to enhance the model and add to the multiple perspectives for the next iteration and new learners. Learners are assessed on their engagement, their growth mindset and ultimately their big ideas and burning questions.