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Marc Chenard
Portland State University

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Let Kids Sleep: The Role of Interdisciplinary Neuroscience Outreach in
Stimulating Brains and Developing Research-Informed Approaches to
Community Concerns

by

Marc Chenard



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Abstract

Northwest Noggin (NW Noggin), an all-volunteer neuroscience education outreach non-profit, serves its community by bringing students, artists, scientists and other participants together for artistic collaboration and learning. The outreach takes place in K-12 schools and other institutions (such as museums, coffee shops and correctional facilities) all over the Pacific Northwest. Neuroscience education outreach generates discourse surrounding community concerns through illuminating the brain-centric qualities of issues and by drawing on neuroscience research to create solutions. The neuroscience research-informed perspectives on these concerns stimulate awareness, create momentum towards evidence-based reform, and can result in policy interventions. This thesis details how NW Noggin outreach helped address chronic sleep deprivation and its associated health risks for teenagers in the Vancouver Public School District. This was achieved when NW Noggin volunteers persistently re-sparked discussion surrounding the start times for high schools in the district while referencing neuroscientific evidence centered around research on sleep and developing brains. Further educational and communal concerns are analyzed in parallel with a demonstration of how NW Noggin works to explore research-informed initiatives and solutions. The efforts of NW Noggin are then positioned in the context of STEM education research by understanding how outreach efforts aim to improve metrics associated with student motivation and performance.

Keywords: neuroscience, education outreach, school start times, sleep, developing brains, community issues, research-informed solutions

Introduction

While many high school students in the Vancouver Public School District were painfully aware of the fact that school began promptly at 7:30 A.M., it came as a shock to the NW Noggin volunteers who were scheduled for outreach one winter morning in 2022. Arriving before the sun rose, many high school students slumped into their desks and appeared half asleep. The NW Noggin volunteers on this occasion included several undergraduates from Portland State University, graduate students from other area schools, and NW Noggin co-founders, Dr. Bill Griesar and artist Jeff Leake. Even some of the budding undergraduates among the outreach volunteers were able to identify Fort Vancouver students experiencing chronic sleep deprivation. While the seasoned neuroscientists in the room were aware of the dramatic impacts of sleep deprivation on health and academic performance, as a result of this outreach visit some of the volunteers and high school students began a larger investigation into the literature on sleep, developing brains, and school start times.

Despite taking place in a wide variety of settings, NW Noggin events often follow a similar structure. First, volunteers will set up tables with instructional materials including colorful neuron sculptures, jars of animal brain specimens, 3D-printed brain models, and pans with human brains (from anonymous organ-donors) for participants to examine and hold. Once the event is underway, every volunteer introduces themselves to the group of students, other participants and fellow volunteers. Introductions are important since volunteers attend from different institutions and departments, while having diverse backgrounds and interests. It is central to NW Noggin's mission to highlight volunteers with different identities, backgrounds, and career aspirations who all share a common interest in the broader field of neuroscience. After introductions comes a call to have K-12 students, teachers and other participants share things they already know about the brain, or ask

questions about a topic of interest. Participants ask questions about things that they are interested in both academically, or that excite their own curiosity, and often ask about topics that pertain to the brains of their loved ones. Following any questions, participants and students are led by artist Jeff Leake and volunteers in neuroscience art activities including crafting pipe cleaner neurons, creating brain cell-shaped gel prints using plants, and more. Finally, all participants are invited to touch the brain specimens if they are comfortable doing so (with gloves). This is often accompanied by more questions, discussion and engagement.

NW Noggin volunteers often explore neuroscience research related to community interest and are able to contribute their own valuable perspectives. Informing participants about neuroscientific discoveries and their implications is important because neuroscience research, like much of contemporary STEM research, is often jargon-filled and granular in nature. A kind of “overfitting” occurs when the experts in neuroscience are zoomed in and connected to their colleagues and research to such an extent that they may not be able to effectively communicate its significance to someone outside their area of study. While this may help in some cases to advance the field, it can make bridging the gap between neuroscientist and layperson more difficult. Because much of the contemporary ground-breaking neuroscience research is federally funded, NW Noggin strives to make it more accessible and directly beneficial to the community that pays for it.

The concerns of a specific community (for example, high school students experiencing sleep deprivation in Vancouver) can be analyzed and ultimately addressed from a multitude of unique perspectives. While a given issue may receive attention, it may not be fully understood - and that is part of why it persists in the community. NW Noggin outreach events, like the one at Fort Vancouver, strive to be mutually beneficial to all of the parties involved. The outreach volunteers push their comfort zones and stretch to answer questions in areas they might still be studying in their academic programs. The community participants contribute their own perspectives, interests

and understanding, and collaborate on art projects while getting to touch and examine real human brains. The direct contact with the public during NW Noggin outreach sparks informed dialogue and engagement with local community concerns.

Chronic Sleep Deprivation, Adolescent Brains, and High School Start Times

It was clear to the Noggin volunteers that Fort Vancouver High School students were not alert enough to be learning optimally. Volunteers even saw students that were asleep in class. This observation generated discussion amongst the undergraduate volunteers and NW Noggin founder Dr. Bill Griesar about the school's start time. After an investigation into the literature on sleep and developing brains, undergraduates discovered that a start time as early as Fort Vancouver's is not only suboptimal for student learning and health, it can rightfully be interpreted as unsafe.

A study conducted in the Seattle School district showed that when the start times of high schools were shifted from 7:50 A.M. to 8:45 A.M., students averaged 34 more minutes of sleep (Dunster et al., 2018). Despite getting up later, student bedtimes did not change significantly as a result of the later start time. This can be attributed to adolescents exhibiting a delayed phase in their circadian rhythms when compared to adults (Taylor et al., 2007). While the reason for this circadian shift is not fully understood, experts discuss several underlying mechanisms for the shift, and explore potential hypotheses grounded in research on evolutionary biology (Crowley et al. 2007). One possible explanation is that adolescents wake up and go to sleep later so that they can remain awake into the hours less dominated by adults, hypothetically allowing them to establish an independent life (Troxel, 2020).

The outcomes from the study by Dunster et al. (2018) were significant - there was a noticeable uptick in student well-being and academic performance. This is likely in part due to adequate sleep playing a crucial role in improving retention and consolidation of memories, thus

improving learning (Rash & Born, 2013). A start time shift of just 55 minutes was associated with reduced sleepiness at school, an improvement in attendance, and a 4.5% increase in median grades (Dunster et al., 2018).

Despite Fort Vancouver High School Center for International Studies being located less than a three hour drive from where so many positive effects had been seen in the Seattle Public schools study, start times remained suboptimal for learning, as well as unhealthy and unsafe. This may be a result of the local community not interpreting the issue through a neuroscientific lens. While some of the symptomology and consequences of early start times may be apparent to neuroscientists, prior to NW Noggin outreach the discourse surrounding this issue was not as brain-centric as the issue itself. The start time was not an unknown concern in the community - parents and legal guardians likely get an earful from their students about it. One survey conducted with a group of high school students found that 61% of them reported being “too tired to get out of bed in the morning” (Short et al., 2013).

It was fascinating to discuss shifting the start time with individuals who did not share a background in biology, neuroscience or other fields in the larger STEM community. They saw the issue, understandably so, as a discussion not of student health and well-being, but rather of scheduling and logistics. Logistics are indeed important and have a nontrivial impact on families, but a change in perspective occurred when Noggin volunteers began engaging and teaming up with students at Fort Vancouver. The issue was now being seen through a neuroscientific lens with research-supported discussion weighing the pros and cons of a later start time in favor of student health. Many of the concerns expressed in response to a suggested later start time centered around buses, bus driver availability, and transportation to and from the school. Another common concern focused on sports practices and the hours after school typically allotted for them. These concerns

are real for parents, guardians, and families, but they all fail to place teenage mental health and well-being as the highest priority.

These logistical concerns can be met with attention and creativity in order to best support families with transportation, and maintain student athletic experiences. During the NW Noggin event at Fort Vancouver, discourse between volunteers sparked potential brain-supporting solutions. One idea, which has a high chance of being embraced by the district, was to manipulate the bus schedule so younger elementary students, who are not typically experiencing the delayed sleep phase, get to school earlier so buses and drivers could be available to take the teenage students afterwards. A proposed solution for the impact on sports was to embed practices throughout the school day. Collegiate athletics often work in this fashion. While these proposed solutions may oversimplify the reality of logistical hurdles, new ideas spawning from outreach volunteers in just a few hours suggests creative logistical solutions may be out there.

The conversation about the early start time did not stop at Fort Vancouver. After the outreach discussion, one Fort Vancouver science teacher created a teachable unit centering around the neuroscience of sleep, developing brains and school start times. Following the persistent NW Noggin blog posts on chronic sleep deprivation and developing brains, the creation of the unit by the Fort Vancouver teacher, and in conjunction with community feedback, Vancouver Public Schools is now shifting to a start time of around 8:45 A.M. for the 2023-2024 school year and potentially beyond.

Neuroscience for Rigorous Study in K-12 and Beyond

How does a concern like teenage sleep deprivation (and all its associated health risks) caused in part by too early of a start time persist in the community when there is ample scientific evidence supporting a solution? One explanation may be that the community largely does not have enough

access to neuroscience education. Within academia, the field of neuroscience is typically not available for formal rigorous study until the undergraduate level. Even then, depending on the institution, it is frequently not offered as a distinct major. Portland State University, for example, does not offer a Neuroscience major, and did not offer its Interdisciplinary Neuroscience minor until the fall term of 2021. The Psychology department focuses on areas distinct from biology, and the Biology department is concerned more with environmental science. Portland State's close proximity to Oregon Health & Science University, with world-class graduate offerings in Neuroscience (Ph.D. programs in Behavioral Neuroscience, Neuroscience, etc.), lends itself to phenomenal mentors and research opportunities for undergraduates in the field. Regardless of its proximity to OHSU and associated resources, PSU still lacked formal neuroscience offerings prior to 2021. The Interdisciplinary Neuroscience minor came about as a result of PSU's Neuroscience Club surveying active undergraduates to see if they would, given the opportunity, be interested in or consider adding the minor to their degree program. After a high level of interest in the minor was expressed by PSU undergraduates, PSU's administration created one. The minor has major-dependent tracks that can be fulfilled with classes from several departments (Biology, Psychology, Philosophy, Public Health, etc.) that broach topics in neuroscience. Before the addition of the minor, an undergraduate student wanting to specialize in neuroscience would have needed to transfer or postpone a formal focus in this area until graduate school at a different institution. What if neuroscience offerings at the undergraduate level were not the first introduction to neuroscience concepts, and brain-centric education was instead interspersed throughout the grades of K-12?

According to the Next Generation Science Standards in Oregon, the only required mentions of neuroscience concepts are twice in grades 3-5, and one time within grades 6-8. In grades 3-5 (Read The Standards, 2023), students are introduced to a model that describes how animals have brains for information processing, and that different animals will respond to stimuli in different

ways. In these same grades, a teacher is asked to convey that animals and plants have internal and external structures that inform survival, growth and reproduction. In grades 6-8, students are supposed to be taught that sensory receptors send information to the brain for immediate behavior and memory storage (Read The Standards, 2023). While these concepts are a good start, and may even coincide ideally with other required materials, the potential upside for increasing required neuroscientific content in K-12 is great. Neuroscience is highly applicable and complimentary for students pursuing diverse fields and paths of learning. Everyone has a brain, and during K-12 education it undergoes rapid and dramatic change. Topics covered could range from neurobiology, neurophysiology, psychopathology, psychopharmacology, to perception and cognition. Introducing neuroscientific concepts at an earlier age, accompanying art and collaboration, also levels the playing field for those who come from families where STEM + Arts (or STEAM) is not emphasized at home.

Neuroscience Education Outreach as a Way of Combating the Leaky Pipeline Phenomenon

The “leaky pipeline” is a term in education research coined by Clark Blickenstaff that describes how in academia, the proportion of women decreases with each career level (Blickenstaff, 2005). The leaky pipeline is a phenomenon that has been shown to be especially prevalent in STEM education (Almukhambetova et al., 2022). The phenomenon has since evolved to show how on the journey from K-12 to the undergraduate level, and then continuing to the graduate/professional level, more students from backgrounds not currently overrepresented in STEM leave the education system. That is, fewer women and those not currently overrepresented complete the STEM education tracks they commence. This is a significant issue in the local STEM community and beyond, and therefore something that NW Noggin outreach strives to address.

Pre-medical students at Stanford University were surveyed regarding their interest in continuing their studies to become physicians. The surveys took place both at the beginning of the students' freshman year and at the end of their sophomore year. In this study, students at Stanford from backgrounds not currently overrepresented showed a more significant drop in interest with continuing as pre meds than did their peers (Barr & Matsui, 2008). Independent of race and ethnicity, women showed an even larger drop in interest associated with taking their pre-medical education journeys to completion (Barr & Matsui, 2008).

The leaky pipeline may be a macroscopic view of the outcomes manifested from three metrics that can be used to predict motivation and learning in STEM students including self-efficacy, science identity, and sense of belonging. Self-efficacy is essentially the belief in one's ability to succeed in tasks or, in a larger sense, a belief in their own capabilities overall. Self-efficacy in adolescents has been shown to predict their academic performance, motivation, well-being, and to impact their career choices (Pajares & Urdan, 2007). In the context of STEM, tasks often require a high degree of analysis, creativity, and perseverance. STEM tasks can include things like experimental design and execution, meaningful interpretation of results, or developing an understanding of complex contemporary research methods. The degree to which self-efficacy can modulate for a student is largely dependent on the opportunities presented to them for engaging in relevant tasks. It turns out that hands-on experiences, like those available to participants at NW Noggin outreach events, may also improve another metric contributing to the persistence of a leaky pipeline.

Science identity is the extent to which a student will feel like and describe themselves as a scientist. In education research, science identity has proved to be pertinent when understanding student retention and persistence in STEM subjects (Trujillo & Tanner, 2014). In that same vein, many of the students who decide not to persist in STEM are every bit as competent as those who persist, yet simply do not identify with the culture of science (Seymour & Hewitt, 2018; Tobias,

1990). Cultural aspects of the STEM community like weed-out classes and harsh grading may be under-examined contributors to student retention (Tobias, 1990).

Sense of belonging is another metric that has been examined in the context of STEM student retention and persistence. One established way of determining STEM students' sense of belonging is by presenting sample statements to them. Following this, students can rate the extent to which they relate or do not relate to the statements, or even place the statements in or outside a silhouette image of themselves (Nealy & Orgill, 2020). The Motivated Strategies for Learning Questionnaire, or MSLQ, works in a similar manner and can be used in conjunction to see where students are in terms of motivation (Pintrich, 1991).

Portland State University, like many urban universities with an R2 research designation, is seeing increasing enrollment of students of color, first generation students, students from low-income backgrounds, and those from immigrant families. This is leading to the undergraduate population, including the small subset volunteering through NW Noggin, becoming more diverse and increasingly representative of the students in the K-12 schools of the region.

As is the case with self-efficacy, science identity can be altered and potentially raised through hands-on interaction with STEM experiences (Kim & Sinatra, 2018). There must be consideration in cultivating spaces that provide hands-on experiences, collaboration with diverse role models, and opportunities to try new tasks within STEM. NW Noggin outreach is likely a positive force for students and participants in improving all three of these metrics. Inviting students and participants to collaborate with diverse NW Noggin volunteers, especially on art projects that favor depth of engagement rather than tests with grades, is an attempt to increase the self-efficacy, sense of belonging, and science identity of those involved.

NW Noggin strives to create spaces and opportunities for K-12 students to observe and interact with peers who model mastery or at least an intermediate level of knowledge in the field of

Neuroscience. Exposure to diverse role models and mentors from NW Noggin can inspire and affect career choices of underrepresented students in neuroscience and the arts.

Interdisciplinarity and Assessment Strategies that Favor Depth of Engagement over Traditional Testing

Interdisciplinarity is the integration of knowledge from multiple disciplines across a central program theme or focus (Ivanitskaya et al., 2002). Despite Portland State University creating an Interdisciplinary Neuroscience minor, interdisciplinary in this context has largely meant an intersection between only the Biology and Psychology departments. NW Noggin outreach illustrates the benefits that could be reaped if interdisciplinarity was embraced to a broader extent in K-12.

Interdisciplinary approaches may help students develop higher order critical thinking skills and therefore become more attractive to top colleges and businesses (Jones, 2010). Interdisciplinary thought can also lead to more advanced epistemological beliefs, the development of metacognitive skills, and a better understanding of perspectives that are derived from and span many fields (Jones, 2010). As a larger scientific community, embracing interdisciplinarity could help to avoid overfitting and remedy the communication issues between expert and layperson. In that same vein, increasing interdisciplinarity could allow more students to illuminate research-informed perspectives on concerns in their communities. NW Noggin strives to model true interdisciplinarity by incorporating art and being open to the inclusion of examples from diverse fields into the brain-centric discussion and activities wherever possible. This also lends itself to avoiding traditional anxiety-provoking testing experiences while still favoring depth of engagement for outreach participants.

There are many useful frameworks for successfully placing art in STEM (STEAM) (Burnaford, 2007). Including art, even though its practices are sometimes viewed as diametrical to

STEM, may foster more understanding through what James Catterall calls conversation and silence (Catterall, 2005). Conversation occurs when the significance, meaning of, or importance of an art piece to other classroom topics is discussed. Silence here refers to the development of internal beliefs about form, meaning, and the execution of ideas (Catterall, 2005). Conversation and silence are apparent in NW Noggin outreach environments due to the emphasis placed on creating space for participant questions about brain related phenomena, art, and more. When thinking about reforming Oregon Science Standards to include more neuroscience concepts, students could stand to benefit from the inclusion of themes spanning many disciplines including art.

Discussion & Implications for Future Research

Several limitations arose when attempting to understand the role of NW Noggin's efforts in generating discourse, forming brain-centric understandings and creating research-informed solutions to community concerns. In the case of addressing sleep deprivation it is worth noting that not all students in Vancouver Public Schools are in support of the later start times. Some students explained that they would rather have more free time after school than a later start time. This is wholly fair, and it's important to remember that the needs and wants of students are different.

While some neuroscience outreach through NW Noggin has been done working with a local homeless youth mentoring organization called p:ear mentor, the larger concern of houselessness in Portland is a brain-centric issue that neuroscience education outreach could work to address. A neuroscientific awareness and understanding of mental health and substance use disorders could potentially lead to increased compassion for individuals experiencing houselessness. In that same vein, creative treatment strategies could be devised based on a foundation of interdisciplinary neuroscience research.

Conclusion

NW Noggin, a neuroscience education outreach non-profit, serves its community by addressing various community concerns from a neuroscientific perspective. This was demonstrated when action was taken to address chronic sleep deprivation in Vancouver Public Schools as a result of outreach. NW Noggin engages with diverse audiences and stakeholders to create dialogue, awareness, and action around these issues, and fosters artistic collaboration and interdisciplinary learning among its volunteers and participants, which enriches their journeys throughout academia. This thesis is intended to inspire more people to join NW Noggin's mission, and the larger mission, of bringing neuroscience education to the community in order to identify community concerns and create research-informed solutions.

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