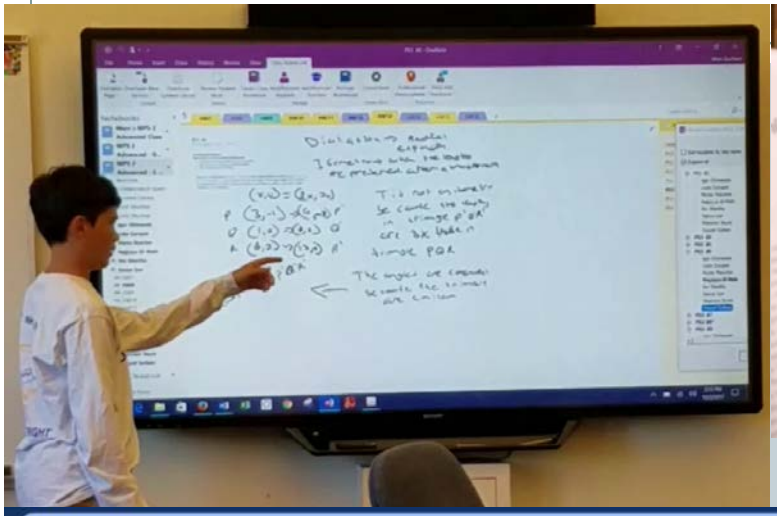
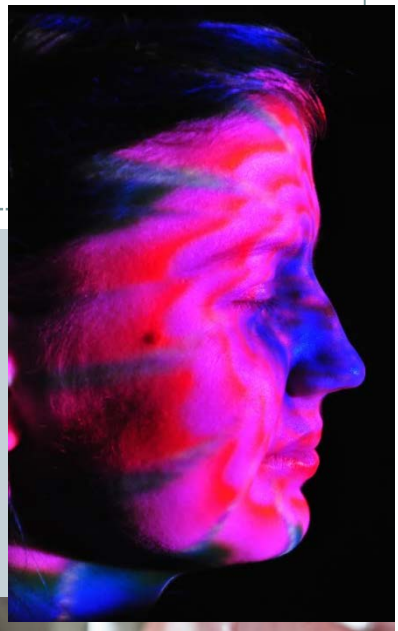
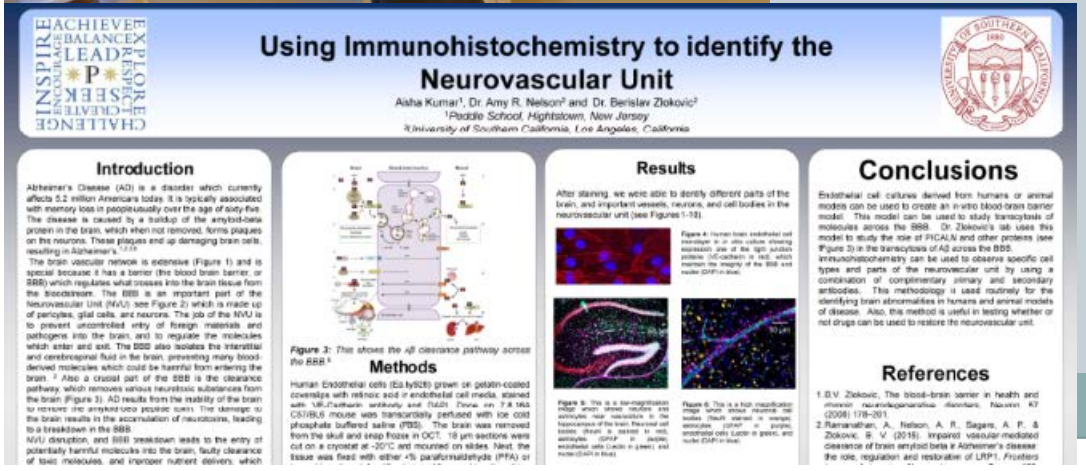
STM, STEM, STEAM…TEAMS? at Peddie







Using Immunohistochemistry to identify the Neurovascular Unit

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Introduction

Alzheimer's Disease (AD) is a disorder which currently affects 5.2 million Americans today. It is typically associated with memory loss in people usually over the age of sixty-five. The disease is caused by a buildup of the amyloid-beta protein in the brain, which when not removed, forms plaques on the neurons. These plaques end up damaging brain cells, resulting in Alzheimer's.[1,2,3,4]

The brain vascular network is extensive (Figure 1) and is special because it has a barrier (the blood brain barrier or BBB) which regulates what crosses into the brain tissue from the bloodstream. The BBB is an important part of the Neurovascular Unit (NVU) see Figure 2) which is made up of pericytes, glial cells, and neurons. The job of the NVU is to prevent uncontrolled entry of foreign materials and pathogens into the brain, and to regulate the molecules which enter and exit. The BBB also isolates the interstitial and cerebrospinal fluid in the brain, preventing many blood-derived molecules which could be harmful from entering the brain. [5] Also a crucial part of the BBB is the clearance pathway which removes various neurotoxic substances from the brain (Figure 3). AD results from the inability of the brain to remove the amyloid-beta peptide toxin. The damage to the brain results in the accumulation of neurotoxins, leading to a breakdown in the BBB.

NVU disruption, and BBB breakdown leads to the entry of potentially harmful molecules into the brain, faulty clearance of toxic molecules, and improper nutrient delivery, which

Figure 3: This shows the Aβ clearance pathway across the BBB.[6]

Methods

Human Endothelial cells (EaHy926) grown on gelatin-coated coverslips with retinoic acid in endothelial cell media, stained with VE-Cadherin antibody and DAPI. Done on 7.8 wks C57BL6 mouse was transcardially perfused with ice cold phosphate buffered saline (PBS). The brain was removed from the skull and snap froze in OCT. 18 µm sections were cut on a cryostat at -20°C and mounted on slides. Next, the tissue was fixed with either 4% paraformaldehyde (PFA) or

Results

After staining, we were able to identify different parts of the brain, and important vessels, neurons, and cell bodies in the neurovascular unit (see Figures 1-10).

Figure 4: Human brain endothelial cell monolayer in in vitro culture showing expression one of the tight junction proteins (VE-cadherin in red), which maintain the integrity of the BBB and nuclei (DAPI in blue).

Figure 5: This is a low-magnification image which shows neurons and astrocytes near capillaries in the hippocampus of the brain. Perfused cell bodies (brain is stained in red), astrocytes (GFAP in purple), endothelial cells (Lectin in green), and nuclei (DAPI in blue).

Figure 6: This is a high magnification image which shows neuronal cell bodies (Nauth stained in orange), astrocytes (GFAP in purple), endothelial cells (Lectin in green), and nuclei (DAPI in blue).

Conclusions

Endothelial cell cultures derived from humans or animal models can be used to create an in-vitro blood-brain barrier model. This model can be used to study transcytosis of molecules across the BBB. Dr. Zlokovic's lab uses this model to study the role of PICALM and other proteins (see Figure 3) in the transcytosis of Aβ across the BBB.

Immunohistochemistry can be used to observe specific cell types and parts of the neurovascular unit by using a combination of complimentary primary and secondary antibodies. This methodology is used routinely for the identifying brain abnormalities in humans and animal models of disease. Also, this method is useful in testing whether or not drugs can be used to restore the neurovascular unit.

References

1. B.V. Zlokovic, The blood-brain barrier in health and chronic neurodegenerative disorders, Neuron 57 (2008) 178–201.
2. Ramanathan, A., Nelson, A. R., Sagare, A. P., & Zlokovic, B. V. (2015). Impaired vascular-mediated clearance of brain amyloid beta in Alzheimer's disease: the role, regulation and restoration of LRP1. Frontiers

Plan for this morning

- Some background on recent thinking about STEM.
- Where we are, 2019
- Some recent developments
- Challenges, and looking ahead

Peddie Strategic Plan (DRAFT)

- Strategic Priority 1: Peddie will enhance our excellence in transformational education…
  - We believe that the educational experience of Peddie transforms our students into more thoughtful and responsible citizens, and that this transformational nature of a Peddie experience … is the most important determinant of Peddie's continued future success.
- For Peddie, two concepts form the bedrock of transformational education:
  - Inspiring intellectual excellence, which requires a remarkably talented faculty and staff, and a continued commitment to curricular innovation.
  - Striving for the highest quality of citizenship, as encouraged by Ambassador Walter Annenberg.
- Action step:
  - Evaluate Peddie's own programs with an eye to pedagogical practices and STM curriculum that can further enhance student learning through increased integration and/or coordination between these areas.

Naturally, a committee

- **Charge:** To research science, mathematics, and technology (STM) programs and to evaluate Peddie's own programs with an eye to pedagogical practices and STM curriculum that can further enhance student learning through increased integration and/or coordination between these areas.

- Met throughout January-May 2018.

- **S**: Kevin Brown, Madeleine Cozine, Shani Peretz, Jennifer McKeever, Karolina Fraczkowska
- **T/E**: Joy Wolfe, Scott Meredith, Tim Corica, Emily Jee, Kevin Brown
- **M**: Andrew Caglieris, Marc Buchner, Mark Sawula, Victoria Montgomery, Tim Corica
- **Administration:** James Truslow (Summer Programs), Peter Park (Admission), Catherine Rodrigue (Asst Head)

(Note that many of these cross disciplinary boundaries)

Three interwoven strands

- STEM education for the student focused on STEM area. Are we successful in supporting/encouraging these students? Are they prepared for future study?
- STEM education for the non-STEM (or, not yet STEM) focused student. Is each student getting the STEM background needed to be an effective citizen and professional in a non-STEM career?
- Technology tools that enhance learning in subject areas inside or outside of STEM. Are we taking advantage of these tools, updating as new tools become available?

Who is a STEM worker?

- Science:
  - Medicine
  - Research
  - Pharmaceuticals
  - Product development
- Technology:
  - Computer science
  - IT work
  - Data visualization/analysis
  - The person they call when they can't figure out their spreadsheet....
- Engineering:
  - Mechanical, electrical, chemical, civil
  - Financial
  - Environmental
- Math:
  - Statistics
  - Analysis of trends, numerical analysis
  - Probability/prediction
  - Economics
  - Applied Mathematics

Strand 1: Preparing future STEM workers

- Science
  - EXP Program
    - First group, summer 2011
    - 20-30 students each year
  - Extensive course offerings
    - APs of course
    - Advanced Research Physics, Astronomy, Forensic Science, Microbiology, Neuroscience of Music, Dissecting evolution, Chemistry of Art and Archeology, Organic Chemistry of food
- Mathematics
  - Broad and deep, across Calculus, Statistics, and Economics
  - After BC Calculus…
    - Multivariable Calculus
    - Linear Algebra
    - Calculus-Based Statistics

2019: **First year ever** that all three post-BC courses offered simultaneously! 41 enrollments, 21/20 M/F

Strand 1: Preparing future STEM workers

- Engineering
  - Course work
    - Introduction to Robotics
    - Engineering Design I, II, III
    - 37 students in Fall 2018
  - Robotics Team
    - Engineering, Programming, Finance subteams.

- Technology/CompSci
  - Students can (and do) take CS courses for 3 years.
  - About 50 students currently in a CS course.
  - Fluid curriculum, project oriented at the upper levels.
  - APCS exam is a foundation, but students go well beyond.
  - "Problem Solving with Design Thinking" elective

2019: Expect about 20 APCS exam takers – the largest number in the 35-year history of the program!

Recent steps in CompSci

- New faculty:
  - 2017: Joy Wolfe, P'03, BA in CompSci (also MEd), 13 years in industry (Mettler, DEC, J&J)
  - 2018: Kari Barkley Hart '04, PhD in Biostatistics, teaching CalcStats, AP Stats.
  - 2019: Greg Koch, BA/MS in CompSci, research in neural networks and image recognition. (Math/Robotics)
- New facilities:
  - 2018: CompSci classroom
  - 2019: Expand CS space to include "maker room"
- New signature programs:
  - 2017: Robotics/CS
  - 2018: Math/CS

2018: First two Math/CS Sig students. Vincent Luo, summer work as an app developer at a startup. Winston Yang, programmer at Columbia U. lab working on security.

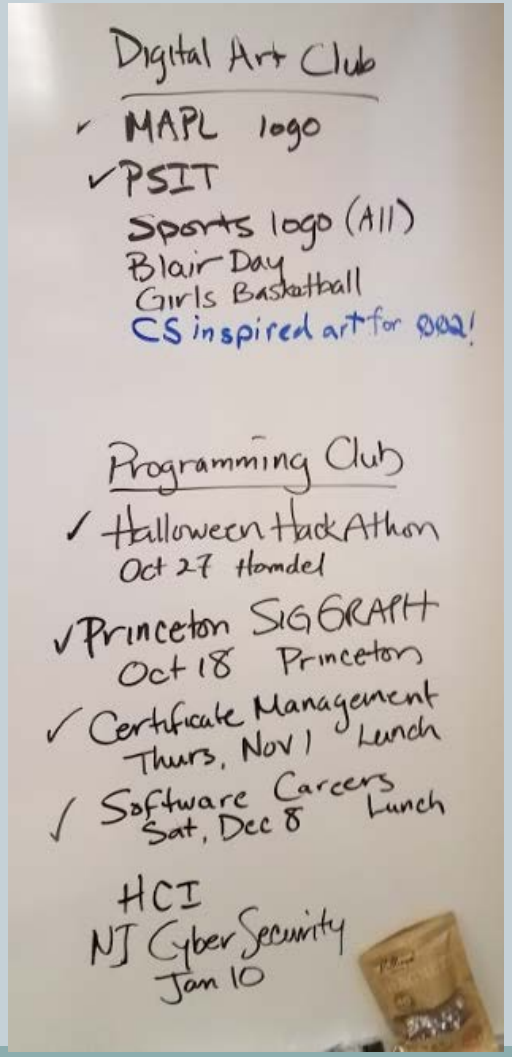
Computer Science Clubs, Activities

- Lunch speakers (Web security, careers in CS)
- Upcoming visit: Prof. Brian Kernighan, Princeton U.

- CS “Culture Bus”

- Digital Arts Club

Classroom “home” for CS

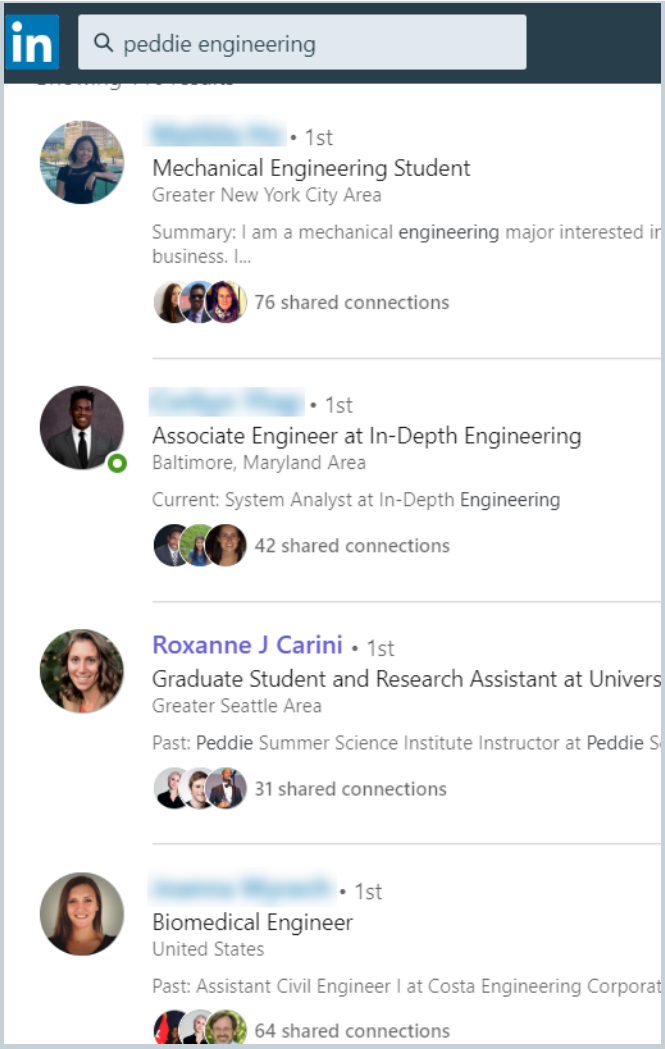


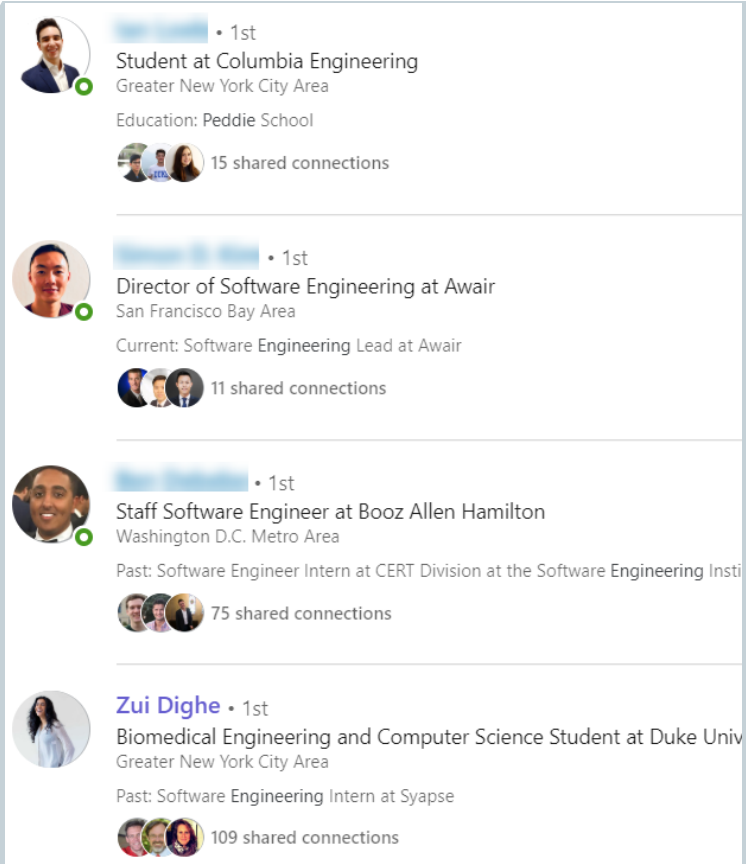
Alumna Success Story….

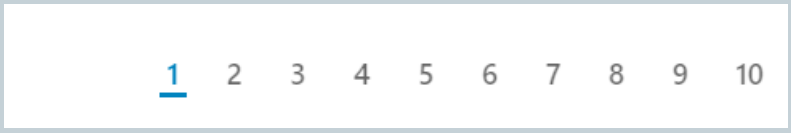
- Roxanne Carini, ‘07
  - Yale, 2011, BS, Applied Mathematics
  - University of Washington, MSE, 2014, Civil and Environmental Engineering
  - University of Washington, PhD (yesterday!), Civil and Environmental Engineering

“Stunningly excellent”… ”absolutely brilliant”

Tons of alumni success!





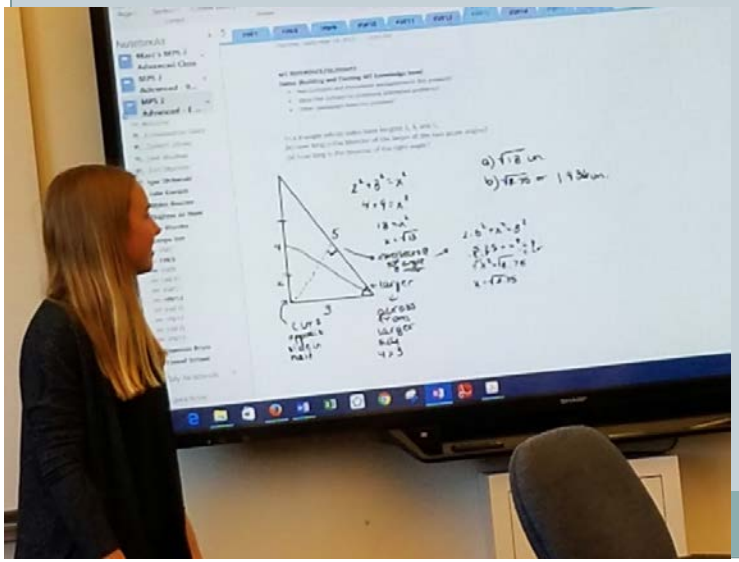


Strand 2: STEM concepts for everyone

- What are the "STEM concepts" everyone needs?
  - Analytical thinking (we've been doing this for a while!) and problem solving, particularly handling novel situations and new information.
  - An understanding of the underpinnings of the digital world, making sense of what technology is capable of (and not).
  - A critical eye to the impacts, ethics, and influences of digital developments.
- Committee: These concepts are best developed in the context of other disciplines, not separated out.

Analytical thinking, problem solving, novelty

- "Liberal arts", taught well: Peddie has always aimed for this.
- Developments in student-centric learning, like the Math Problem Solving (MPS) sequence.
- The skills we need keep changing - no longer learn everything in school.



"I started working at ESPN six years ago. At this point, we aren't using <u>any</u> of the tools we were using when I started." Brendan Houle '03

The underpinnings of the digital world

- Exposure to coding, but in the service of a goal (math, science, art).
- For example, Python coding project in MPS2 connected to learning about angles/polygons.
- Google's algorithms as an application of matrices.

main.py

```
1  import turtle
2
3  Timmy = turtle.Turtle()
4  for i in range(5):
5    Timmy.forward(20)
6    Timmy.left(360/5)
7  Timmy.penup()
8  #Timmy.forward(60)
9  Timmy.pendown()
10 for i in range(8):
11   Timmy.forward(20)
12   Timmy.left(360/8)
13
14 Timmy.penup()
15 #Timmy.forward(60)
16 Timmy.pendown()
17 for i in range(10):
18   Timmy.forward(20)
19   Timmy.left(360/10)
20 Timmy.hideturtle()
21
```

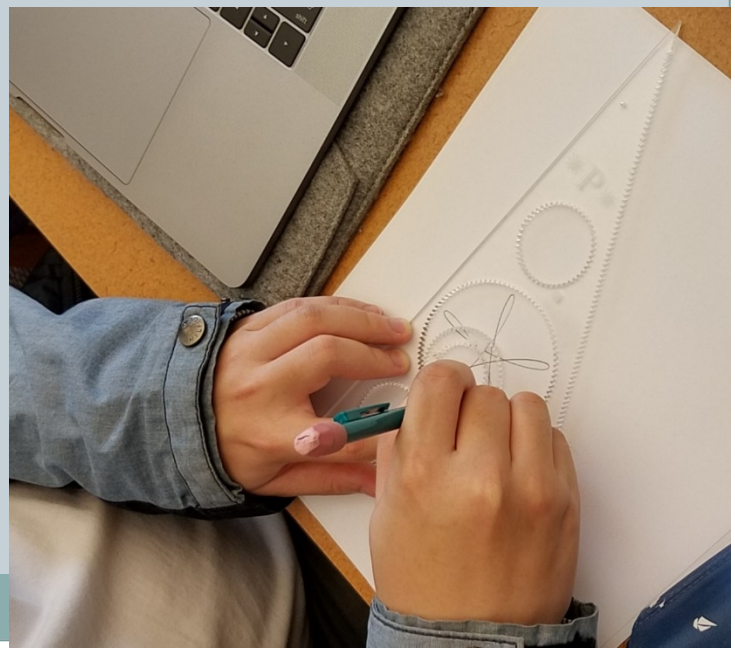
Result

Impacts, ethics, and influences

- Readings, discussions, in English and History
- Electives:
  - The Big Questions: Ethics in STEM, Alyssa Corcoran
    - ...an interdisciplinary course in applied ethics...examine how these principles apply to major contemporary issues within the STEM fields. Topics include abortion, genetic enhancement, and euthanasia; animal testing and climate change; and robotics, algorithms, and optimization.
  - Navigating The Influencing Machine: Truth, Power, and Trust in the Media, Grant Edwards
    - ...This course will examine how individuals communicate, interact, and understand, not just with other people, but also with the entities that filter and ultimately present information about the world around them....students will explore topics ranging from truth in advertising and reporting to the power dynamics that dictate relationships online, all in an effort to develop and refine their abilities to navigate the increasingly complex "series of tubes" that dominates and facilitates their daily existence.
- Of course, strong STEM depends upon great teachers!

Strand 3:Technology tools that enhance learning

- Why?
  - Improve learning (goal 1!)
  - Learn about technology by seeing what is possible, seeing it in action.
- VR trips; FabLab-created tools, Maple, MATLAB, etc.
- Emily Jee, Director of Academic Technology



Looking ahead

- For STEM-focused students: Expanded use of coding within STEM courses and in the EXP program, so that all STEM-focused students have a solid background in coding.
- For everyone: Continued efforts to include more STEM concept learning into disciplines, and to provide exciting options for student to try-out STEM work.
- In the classroom: Scouring the educational technology world for tools that are effective, and fit with Peddie's mission.

Questions, thoughts, ideas welcome!

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