Advanced Student Research in Secondary Schools: Three Exemplars

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Abstract

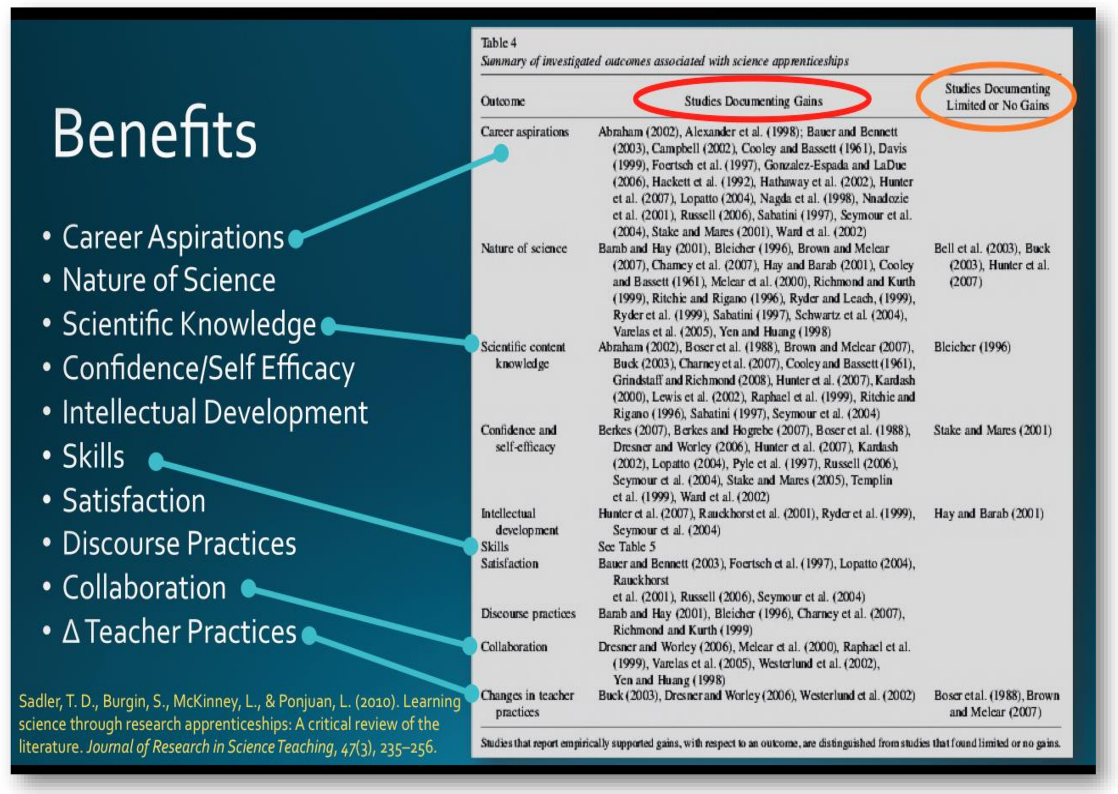
A comprehensive review of recent research on science research apprenticeships has documented multiple benefits, including scientific knowledge and skills, career aspirations, and collaboration abilities. Subsequent research finds authentic student research (ASR) as a "signature factor" contributing to value-added outcomes. Diverse ASR models, however, continue to emerge from rapid growth in secondary school programs. Three distinct exemplars are compared: (1) The Illinois Mathematics and Science Academy (IMSA), (2) The Princeton International School of Mathematics and Science (PRISMS), and (3) Gwendolyn Brooks College Preparatory Academy. An explicitly developmental approach — throughout and integral to the secondary school curriculum — is indicated in preparation for the ASR experience and for ultimate success.

Three Exemplars

The Cases

Each of these three exemplars are distinct among the others, yet all are exceptionally high performing. Cases vary by demographics, curriculum architecture, and features of student research experiences. All three schools are selective enrollment ("magnet"). PRISMS is a privately funded international school, while IMSA and Brooks are both public funded. The schools also vary by size, history, community setting, and access to research institutions.

Figure 1: Research on the benefits of student research apprenticeship from a review by Sadler, Burgin, McKinney, and Ponjuan (2010).



Rogg, S.R. (November 13, 2014). PRISMS Research: Learning to Inquire ≡ Inquiring to Learn. National Association of Biology Teachers (NABT). Cleveland: OH.

Conclusions

As Figure 1 illustrates, student research apprenticeships in science are associated with a variety of desirable outcomes. ASR is also found to be a "signature factor" contributing to value-added outcomes (Subotnik, Tai, Almarode, & Crowe, 2013; The University of Chicago, 2011). As ASR expands, it can be expected that contexts and critical effectors of programs will vary widely. Examination of these exemplars suggests that ASR experiences may be robust with respect to characteristics of the host school. Factors external to the school proper, such as mentor qualities and research authenticity, are key. The school is facilitative. Together, these findings appear to support active promotion of ASR more deeply into and throughout secondary education.

Subotnik, R. F., Tai, R. H., Almarode, J., & Crowe, E. (2013). What are the value-added contributions of selective secondary schools of mathematics, science and technology? - preliminary analyses from a U.S. national research study. Talent Development and Excellence, 5(1), 87–97.

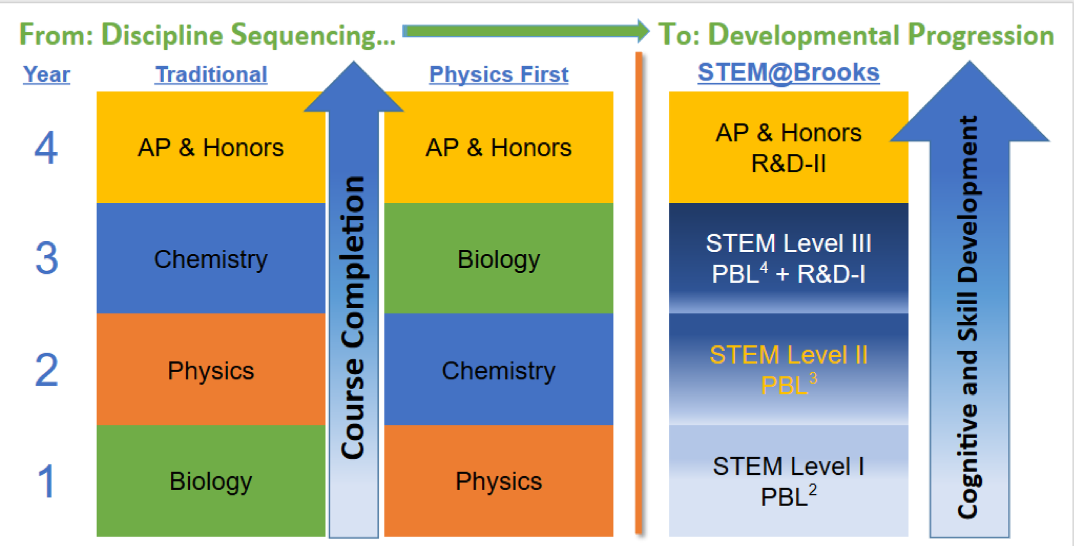
The University of Chicago. (2011). Study of the Impact of Specialized Public High Schools of Science, Mathematics, and Technology. Retrieved March 9, 2018, from https://arc.uchicago.edu/reese/projects/study-impact-specialized-public-high-schools-science-mathematics-and-technology

Gwendolyn Brooks College Preparatory Academy

1

- STEM@Brooks was established AY2014-15.
- Critical Features of the STEM Core:
  - *BSCS Science: An Inquiry Approach* paired with *Core Plus Math*
  - Project-Based Learning (PBL) integral to each course.
  - Teachers are dual certified in mathematics and science.
  - Teachers share common design/prep blocks in grade level PLCs.
- ESEY = "Every Science Every Year" NGSS proficiency-based progression.
- PBL⁴ = Problem-, Project-, Proficiency-, and Place-Based elements.

Figure 2: The STEM@Brooks developmental progression curriculum.



STEM@Brooks is designed to achieve continuous and coherent **cognitive and skill development** in multidisciplinary science coupled with mathematics, technology, and engineering. Accelerated pathways prioritize PBL[4] to R&D application and transfer of learning in authentic "real world" contexts (PBL[4] dimensions illustrated are: (1) Proficiency-, (2) Project-, (3) Problem-, and (4) Place-Based Learning). In contrast, traditional curriculum models are defined as a ***discipline coverage*** sequence.

Figure 3: The Every Science Every Year (ESEY) model.

STEM@Brooks ESEY Design Specifications

1. Provide the equivalence or better of three laboratory courses (CPS):
   a. Biology (completed by Year 2 for Illinois Science Assessment)
   b. Chemistry (completed by Year 3 for SAT)
   c. Physics (completed by Year 3 for SAT)
2. Enact NGSS explicitly and coherently (ISBE, CPS).
3. Incorporate NGSS Geoscience and Environmental Science (ISBE, CPS).
4. Foster retention, application, and transfer of learning through PBL[4].
5. Support pathways for accelerated and advanced study (AP/Dual Credit).
6. Connect explicitly and powerfully with:
   a. mathematics (INT),
   b. engineering (ENG), and
   c. technology (CS).
7. Comply with CPS and ISBE anticipated ESSA licensure requirements.

PBL[4]: As described in our LEAP proposal, STEM@Brooks "fourth power PBL" leverages: problem-, project-, place-, and proficiency-based learning opportunities in order to (1) apply and transfer learning, and (2) promote new learning.

Figure 4: Problem-based learning core leads to research option.

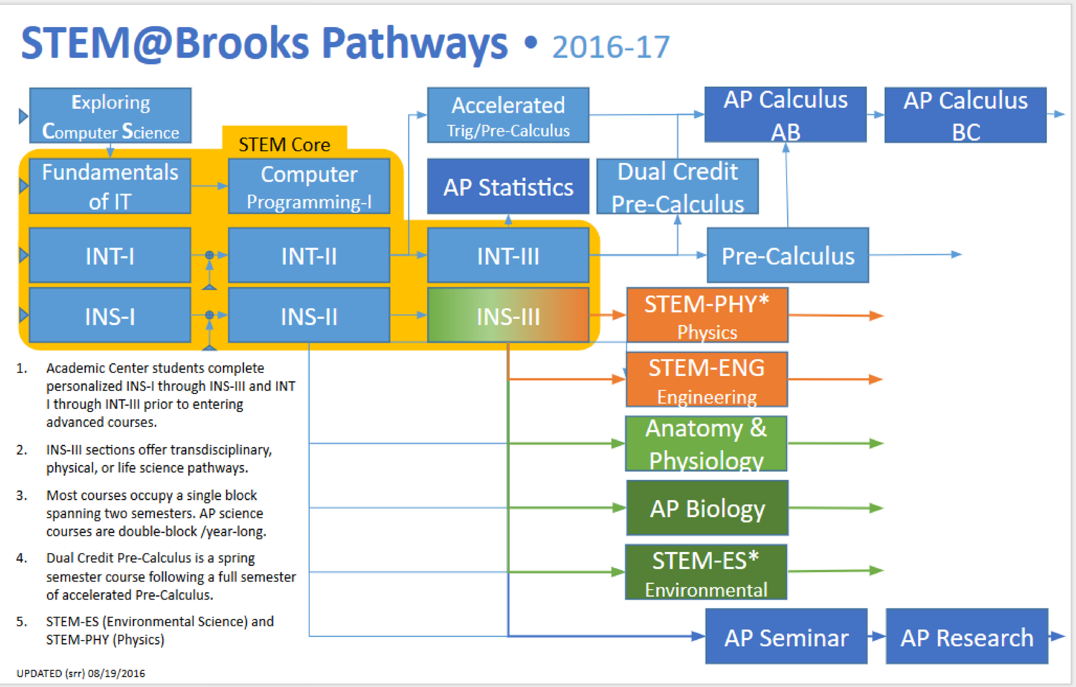
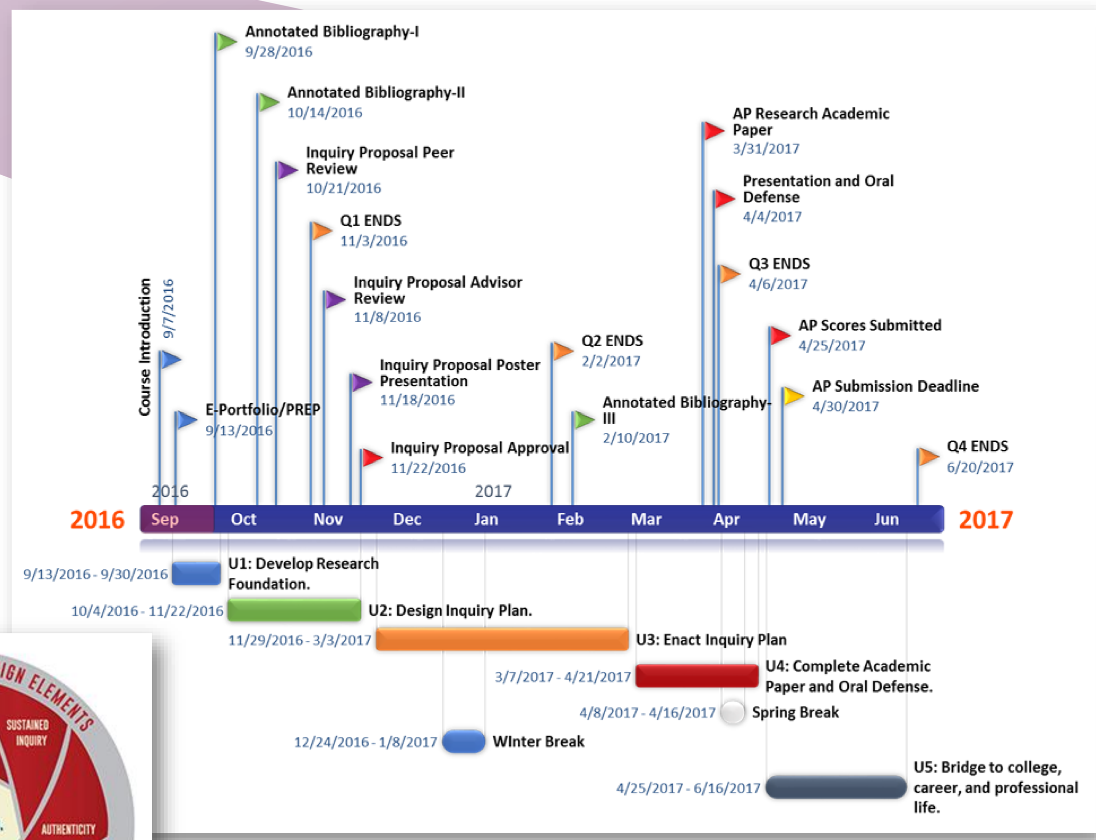


Figure 5: AP Capstone Research timeline. Also shown, Buck Institute's Gold Standard PBL graphic (Larmer, 2015) and scenes from the end of year "public product" Brooks STEM Expo event.



Larmer, J., Mergendoller, J. R., & Boss, S. (2015). *Setting the standard for project based learning: a proven approach to rigorous classroom instruction*.

Illinois Mathematics and Science Academy

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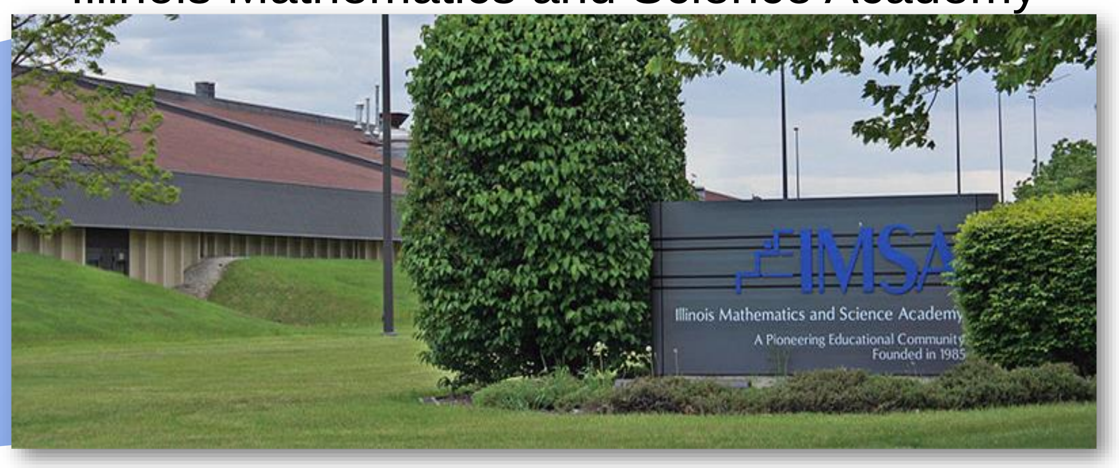


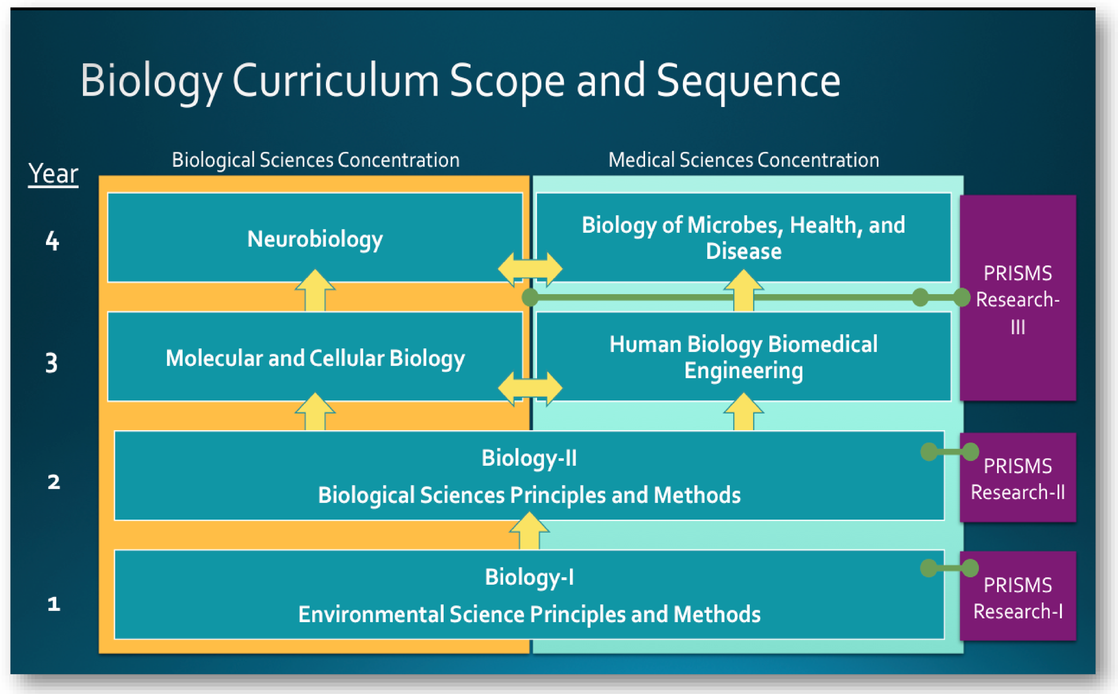
- Founded in 1985, IMSA is the nation's second oldest selective statewide specialized STEM high school (grades 10-12).
- Students elect Student Inquiry and Research (SIR) in their junior and/or senior year. Approximately 95% do SIR either or both years.
- Wednesdays are Inquiry Day (I-Day); regular classes do not meet.
- SIR is on- or off campus with mentor.
- Sites include: Fermi National Laboratory, Argonne National Laboratory, the University of Illinois at Chicago, Northwestern University, Loyola University Medical Center, and the University of Chicago.
- SIR students typically generate or analyze extant data derivative of the mentor's agenda and setting.

Princeton International School of Mathematics and Science

3

- PRISMS was founded with authentic research and global studies as the core of its curriculum.
- Every student was to be engaged in authentic and progressive research continuously throughout their high school career.
- Research@PRISMS was the "central nervous system" with intentional reciprocal relationships between courses and research.
- Wednesdays were Research Day (R-Day); regular classes did not meet.

Figure 6: The original PRISMS model with integral research each year.



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