Sean P. Robinson

Curriculum Vitae

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MIT Physics: http://web.mit.edu/physics/people/academic/robinson_sean.html

Summary

- Associate Director of the MIT Physics Junior Lab, an internationally recognized standard for laboratory teaching in physics. Specialty in teaching rigorous and creative problem solving, careful record keeping, written and oral communication technique, data analysis and statistics, physical laboratory skills, and development of professional identity. Strongly engaged in extended community of physics educators via national leadership service, scholarly work, and active participation in professional societies.
- Award-winning leader in the field of phyiscs advanced laboratory education, recognized for extensive experience in developing and applying modern research-based education methods and technology to advanced physics teaching in both online and hands-on laboratory learning environments.
- Senior Manager and co-founder of the MIT Physics Education Group, home for academic instructional staff at MIT with a professional specialization in physics education, leveraging years of experience in complex technical and personnel work environments and in leading organizations through structural change.
- Research expertise in theoretical physics (quantum field theory, general relativity, and black hole thermodynamics) and physics education research (lab curriculum R&D). Additional research experience in computational dynamical modeling of biological systems, quantum computation, and space plasma (solar wind) physics.
- US Citizen

Education

Massachusetts Institute of Technology — Cambridge, MA, 1999–2005.
Ph.D. degree in Physics (Theoretical Particle Physics).
Thesis: *Two Quantum Effects in the Theory of Gravitation.*
Thesis adviser: Prof. Frank Wilczek.

Massachusetts Institute of Technology — Cambridge, MA, 1995–1999.
B.S. degree in Physics; Minor in Earth, Atmospheric, and Planetary Science.
Thesis: *Single Function Call Probabilistic Quantum Algorithm for Searching an Ordered List.* Thesis adviser: Prof. Edward H. Farhi.

Marshfield Public Schools — Marshfield, MA, 1982–1995.

Additional Coursework — Over 30 professional development courses, training seminars, summer schools, and workshops on technical skills in science and engineering (including software development), management technique, emerging STEM education topics, and education research methods (2012–present).

- ▷ AAPT Workshop: Intermediate and Advanced Labs, *AAPT SM2025 Workshops*, August 2025
- ▷ AAPT Workshop: Bridging Classical and Quantum Realms Using Nuclear Magnetic Resonance, *AAPT SM2025 Workshops*, August 2025
- ▷ AAPT Workshop: AI in Support of Physics Labs, *AAPT SM2025 Workshops*, August 2025
- ▷ PEER Field School, *Professional Development for Emerging Education Researchers* (MIT), July 2024
- ▷ PEER Virtual Gateway Workshop, *Professional Development for Emerging Education Researchers*, October 2023
- ▷ AAPT Workshop: Intermediate and Advanced Labs, *AAPT SM2023 Workshops*, July 2023
- ▷ AAPT Workshop: PIRA Lecture Demonstrations I & II Condensed, *AAPT SM2023 Workshops*, July 2023
- ▷ 8.998: Teaching and Mentoring MIT Students, *MIT*, Spring 2023 (audited)
- ▷ AAPT W09: Implementing and Assessing Writing Across the Physics Curriculum, *AAPT WM2020 Workshops*, January 2020
- ▷ AAPT W10: The Architecture of Glowscript vPython, *AAPT WM2020 Workshops*, January 2020
- ▷ AAPT W21: Trinket Workshop: Teach with Code, *AAPT WM2020 Workshops*, January 2020
- ▷ AAPT W05: Visualizing Contemporary Physics, *AAPT SM2019 Workshops*, July 2019
- ▷ AAPT W22: Teaching Innovation and Entrepreneurship in Physics, *AAPT SM2019 Workshops*, July 2019
- ▷ Presenting Data and Information, *Edward Tufte* one-day course, June 2019
- ▷ AAPT W43: Effective Practices for Final Projects, *AAPT SM2018 Workshops*, July 2018
- ▷ AAPT W33: PICUP Integrating Computation Into Undergraduate Physics Education, *AAPT SM2018 Workshops*, July 2018
- ▷ Project101x: Introduction to Project Management, *AdelaideX* online, Fall 2017 (completed)
- ▷ AAPT W38: Intermediate and Advanced Labs, *AAPT SM2017 Workshops*, July 2017
- ▷ BAMM.101x: Analytics in Python, *ColumbiaX* online, Summer 2017 (completed)
- ▷ AAPT W25: What Every Physics Teacher Should Know About Cognitive Science, *AAPT SM2016 Workshops*, July 2016
- ▷ 7.QBWx: Quantitative Biology Workshop, *MITx* online, Spring 2016 (completed)
- ▷ AAPT W18: Creating Interactive Web Simulations Using HTML5 and JavaScript, *AAPT SM2015 Workshops*, July 2015

- ▷ AAPT W31: Creating JavaScript Simulations and Electronic Books for Computers and Tablets, *AAPT SM2015 Workshops*, July 2015
- ▷ HTML5.1x: Learn HTML5 from W3C, *W3Cx* online, Summer 2015 (completed)
- ▷ POPX1.1x: The Rise of Superheroes and Their Impact On Pop Culture, *SmithsonianX* online, Spring 2015 (completed)
- ▷ NOAA Coastal Inundation Mapping, *NOAA Office of Coastal Management* training course, Spring 2015
- ▷ HKU01x: Epidemics, *HKUx* online, Fall 2014 (completed)
- ▷ Introduction to Nonlinear Dynamics & Spatial Pattern Formation, *New England Complex Systems Institute* short course, April 2014
- ▷ 12.340x: Global Warming Science, *MITx* online, Spring 2014 (completed)
- ▷ 2.03x: Dynamics, *MITx* online, Fall 2013 (audited)
- ▷ CX202: Complex Systems Modeling and Networks, *New England Complex Systems Institute* summer school, June 2013
- ▷ CX201: Complex Physical, Biological, and Social Systems, *New England Complex Systems Institute* summer school, June 2013
- ▷ Stat2.1X: Statistics, *BerkeleyX* online, Spring 2013 (completed)
- ▷ 6.002x: Circuits and Electronics, *MITx* online, Spring 2012 (completed)

Positions Held

Academic Teaching Appointments

- ▶ **Lecturer** (2009–present), **Associate Director of the Helena Foundation Junior Laboratory** (2014–present), and **Senior Manager of the Physics Education Group** (2022–present), MIT Dept. of Physics. Coordination of advanced laboratory instruction in Experimental Physics I & II (8.13 & 8.14), serving about 70 students per year; including management of curricular content; coordinating up to 9 graduate and undergraduate student staff, with 4 faculty instructors; and development and implementation of research-based curriculum reforms. Responsible for management of a 4195 sq.ft. laboratory facility (engaged in work requiring management of radiological, biological, chemical, laser, magnetic, and electrical hazards); its operating budget, grants, and gift funds; its extensive collection of bespoke scientific apparatus; and up to 3 technical staff. Additionally, head of the MIT Physics Education Group, with oversight of the Group's personnel (about 14 physics education professional staff), projects, and programs which both support the MIT Physics academic program and contribute to scholarship in the field of physics education via dissemination research and development results.
  Major projects and implementations include:
  - Collaborated with MIT Open Learning to perform a major refactor of Junior Lab course materials as presented in Canvas, aligning education design principles with in-class realities of the student-centered learning environment. With A. Kessler and C. Romanov. (2024)
  - Collaborated with MIT Open Learning to utilize Junior Lab as the first user-end implementation of a live MITx-Canvas integration of course materials, paving the way for wider adoption of this technology across MIT. With project manager M. Davies. (2022–2024)

- Helped lead the Junior Lab team's response to COVID-19 teaching restrictions, developing new curricular material, procedures, and frameworks which maintained hands-on laboratory education throughout the remote learning period. This included designing, assembling, and shipping dozens of equipment kits (containing Red Pitaya digital measurement systems, pairs of CosmicWatch particle detectors fabricated by hand by Junior Lab staff, and experimental accessories) to remote students around the world for the performance of advanced physics experiments. (2020–2021)
- Led efforts to form the MIT Physics Education Group by consolidating the Physics Department's scattered academic instructional staff, including those in Junior Lab, into a new administrative unit with personnel policies that promote long-term career paths and professional growth within the Department; while also facilitating collaborations with colleagues outside the Group, both within and beyond of MIT. (2019–2022)
- Led the Physics Department's efforts within a coalition of MIT-internal groups (notably, the MIT Radio Society and AeroAstro Engineering Department) and external funding partners to refurbish a defunct weather radar system on MIT's Building 54 tower roof into the new "Medium Radio Telescope" at a budget of $1.9M, all while navigating the complexity of competing efforts from simultaneous and adjacent capital projects. The new facility brings modern radio research capabilities to campus, including an operational emphasis on education in radio astrophysics which is now heavily utilized for MIT Physics undergraduate student projects. (2018–2023)
- Partnered with MIT OpenCourseWare to produce OCW Instructor Insights for 8.13 & 8.14 in the OCW Educator initiative, documenting the principles and mechanics behind the course design. With project manager S. Hansen. (2016–2017)
- Helped lead the development and implementation team in reformulating Junior Lab course materials into a blending-learning format using MOOC tools based in MITx, a then-novel use of such tools. With G. Roland. (2013–2016)
- Developed and implemented new Raman Spectroscopy experiment for 8.14, with T. Greytak. (2011–2015)
- Implemented new "exploratory experiment" project and associated *Edward C. Pickering Award for the most Outstanding & Original Project in the MIT Physics Junior Lab* in 8.14 curriculum, with I. Chuang and J. Duarte. (2011)
- Developed and implemented new Optical Trap experiment for 8.13 & 8.14. With I. Chuang and S.C. Wasserman. (2011)
- Helped lead major Junior Lab curriculum reforms, introducing assignment sequences that utilize education design principles to scaffold essential skill building towards learning goals of professional identity formation. Resulted in stabilized enrollments and positive learning outcomes on several metrics. With Junior Lab faculty. (2010–2012)
- Arranged receipt of a significant gift-in-kind donation of an NMR magnet from Bruker Corporation for the 8.14 Quantum Information Processing experiment. (2010)
- *See also*: items listed below under publications, grants, and "Professional Activities, Service, and Awards", in particular projects executed within professional society leadership.

Additional duties include academic advising to the "physics flexible" degree program (about 75 graduates per year); member of departmental Education Committee; departmental coordinator for environmental, health, and safety efforts,

including regulatory compliance and staff training; and supervision of undergraduate research projects in theoretical and experimental physics.

- **Technical Instructor**, MIT Dept. of Physics. Provided instructional and lab management support for Experimental Physics I & II (8.13 & 8.14, about 70 students per year). Section leader in introductory subject Physics I (8.01, 47 students). Additional duties included management of the Physics Department's graduate student teaching staff (about 35 students per semester). (2007–2008)
- **Graduate Teaching Assistant**, MIT. Particle Physics of the Early Universe (8.952), Fall 2004; Experimental Physics I (8.13), Fall 1999–2004; Experimental Physics II (8.14), Spring 2000.
- **Undergraduate Teaching Assistant**, MIT. Experimental Physics I (8.13, course material preparation), Summer 1998; Observing Stars and Planets (12.401), Spring 1998; Hands-On Astronomy (12.409), January 1998.

Administrative Staff Appointments

- **Academic Administrator**, MIT Dept. of Physics. Responsible for academic operations in the Physics Department, including management of the Physics Academic Programs Office and 5 office staff. Oversight of academic programming, record keeping, statistical reporting, advising, and recruitment for 250 doctoral students (including admissions) and 200 undergraduate majors. Administration of academic subjects serving 1400 students per semester. Evaluated and administered web-based educational technologies. Succesfully maintained first place status in U.S. News & World Report rankings of physics graduate programs. Additional duties included section leader in Physics I (8.01, 87 students), co-supervision of undergraduate research in theoretical physics, and management of the Physics Department's graduate student teaching staff (about 35 students per semester). (2008–2009)
- **Space and Renovation Manager, MIT Green Center for Physics**, MIT Dept. of Physics. Project management for Physics Department in construction of a midsized facility for physics research, education, and administration. Approximately \$60M and 300,000 sq.ft. in new construction, renovation, and life safety upgrades. Extensive coordination, negotiation, and communication across operational units with diverse professional cultures. Additional duties included facilities management for Physics Department laboratories and offices; and research in theoretical physics. (2005–2007)

Academic Research Appointments

- **Graduate Research Assistant**, MIT Center for Theoretical Physics. Research in theoretical particle physics and gravitation under Prof. Frank Wilczek, leading to Ph.D. thesis: *Two Quantum Effects in the Theory of Gravitation.* (2000–2005)
- **S.B. Thesis Student**, MIT Dept. of Physics. Research in quantum information theory under Prof. Edward H. Farhi, leading to S.B. thesis: *Single Function Call Probabilistic Quantum Algorithm for Searching an Ordered List.* (1998–1999)
- **Undergraduate Researcher**, MIT Center for Space Research, Space Plasma Group. Research in solar wind physics, primarily in interplanetary shocks. Analysis of large multivariate time series data sets from various spacecraft, including Voyager 2, IMP 8, and Ulysses. Supervisors: Alan Lazarus and Karolen Paularena. (1997–1999)

Other Appointments

- **Stock Room Attendant**, MIT Physical Plant. Retrieved supplies and materials from central stock facility necessary for MIT Repair & Maintenance workers to complete daily work orders. Required knowledge of parts used by several trades, including electrical, lighting, plumbing, and pipefitting. Supervisor: Tammy Doyle. (1996–1997)
- **Apprentice plumber**, MacKinnon Plumbing. Worked under supervision of master plumber on midscale construction projects and private residences. Learned basic skills and design aspects of several trades, including plumbing, pipefitting, HVAC, and fire safety systems. Supervisor: Michael MacKinnon. (1996–1997)
- **Dishwasher and busboy**, The Fairview Inn, Marshfield, MA. (1993–1995)

Professional Activities, Service, and Awards

Awards & Honors

- **Special Recognition** for "outstanding support in organizing the AAPT Summer Meeting", American Association of Physics Teachers: 2024.
- **Reichert Award for Excellence in Advanced Laboratory Instruction**, American Physical Society. Cited for "pedagogical excellence that extends to the broader advanced physics laboratory community": 2022.
  Note: highest award granted in the physics subfield of laboratory education.
- **Area Committee of the Year** (as member of Committee on Laboratories), American Association of Physics Teachers: 2019, 2021.
- **Buechner Faculty Teaching Prize**, MIT Department of Physics: 2012.
- **Infinite Mile Award**, MIT School of Science: 2006, 2015.
  For Outstanding Achievement in the Department of Physics.
- **Spot Recognition Award**, MIT School of Science: 2005, 2007, 2012.
- **Erdös number** (mathematical collaboration network ranking): four.

Professional Service and Society Memberships

- **Advanced Laboratories Physics Association**
  - Member (2009–present).
  - Treasurer (2018–2024), elected by Membership for one 4-year term, with additional half-term by special appointment of the Board.
    - Served as member of the Executive Board, responsible for accounting and bookkeeping of ALPhA's financial resources.
    - Oversaw and executed transition of financial procedures to comply with Generally Accepted Accounting Practices for non-profit corporations, including a transition to accrual basis double-entry bookkeeping aligned with the Universal Chart of Accounts v3.0.
    - Coordinated formal incorporation as non-profit entity, including co-authoring (with E. George of Wittenburg U.) new bylaws and new corporate practices and procedures; successfully advocating to both the Board and Membership that they vote to adopt this new legal structure for ALPhA in 2020; legally incorporating under Delaware state law; and succeeding in formal recognition of 501(c)(3) status by the IRS. (2018-2023)
    - Managed finances of BFY3 (2018) and BFY4 (2023) national conferences. Responsible for collection of registration fees from individual and corporate attendees, paying vendors and insurance providers, bookkeeping, and financial reporting.

- ▷ Managed finances for Round 9 of the ongoing Single Photon Detector project, helping physics programs purchase high-performance single-photon counting modules (SPCM-EDU) from Excelitas, Inc. with exclusive availability and educational pricing for ALPhA members; enabling the expansion of experiments using quantum-entangled photon pairs into a broad range of teaching laboratory programs by making the most expensive component of the experimental apparatus more affordable. Made possible by a Venture Grant in partnership with AAPT. (2019–2020)
- ▷ Helped successfully negotiate with vendor Pacer, Inc. to take over the purchasing, storage, and shipping of the Excelitas SPCM-EDU units in partnership with ALPhA's management of exclusive customer eligibility, starting with Round 10 of the Single Photon Detector Project. (2022)

- Organized and hosted special open house event at the MIT Physics Junior Lab for advanced laboratory instructors in conjunction with APS March Meeting in Boston, MA (2019).
- Coordinated national *ALPhA Vaccum Pump Giveaway Project* (with A. Dawes of Pacific U.) between ALPhA leadership, MIT Physics Department, and Kimball Physics Inc., to give away surplus laboratory equipment to needy physics programs across the US, intending to serve as a template for similar future projects. (2014)
- Coordinated a second ALPhA-Kimball partnership for a surplus equipment give-away (with R. Peterson of U. of the South). (2017–2018)
- Society meeting attendee: BFY* 1 (2012, Philadelphia); BFY 2 (2015, College Park); NERM† 2017 (Amherst); BFY 3 (2018, Baltimore); vBFY (2021, virtual); NERM 2022 (Bridgewater); BFY 4 (2023, Chico); ALPhA Coordinated Regional Meeting (2025).

► **American Association of Physics Teachers**

- Member (2008–present).
- Area Committee on Laboratories, appointed (2019–2022).
  - ▷ Task Force on Mission Statement, member (2019–2020), with D. Dounas-Frazer (Western Washington U.) and Nathan Powers (Brigham Young U.). Helped lead community discussion and debate leading to successful adoption of new Mission Statement, which I helped author.
    Note: This Task Force's work was cited by AAPT leadership as a model process which should be extended to AAPT's 18 other Area Committees, and was a significant factor in the Committee being named as Area Committee of the Year.
  - ▷ Working Group on Technical Competencies, member (2019–present).
  - ▷ 2021 Area Committee of the Year.
  - ▷ 2019 Area Committee of the Year.
- Conference host institution organizer: NESS‡ 2025 (MIT); Summer Meeting 2024 (Boston).
- Society meeting attendee: Topical Conference on Advanced Labs & SM§ 2009 (Ann Arbor); SM 2012 (Philadelphia); WM¶ 2013 (New Orleans); WM 2014 (Orlando); NESS‖ 2012 (Braintree); SM & PERC 2015 (College Park); SM 2016

*BFY = *Conference on Laboratory Instruction Beyond the First Year of College*
†NERM = *ALPhA New England Regional Meeting*
‡NESS = *AAPT New England Section Spring Meeting*
§SM = *AAPT Summer Meeting*
¶WM = *AAPT Winter Meeting*
‖NESS = *AAPT New England Section Spring Meeting*

(Sacramento); SM 2017 (Cincinnati); SM 2018 (Washington, DC); SM 2019 (Provo); WM 2020 (Orlando); SM 2020 (virtual); WM 2021 (virtual); SM 2021 (virtual); WM 2022 (virtual); SM 2023 (Sacramento); WM 2024 (New Orleans); SM 2024 (Boston); NESS 2025 (MIT); SM 2025 (Washington, DC).

- **Gordon Research Conference** series on *Physics Education and Research*
  - Series attendee (2010-2018, biannual).
  - Vice co-Chair, with Shane Larson (Northwestern U.), elected by series attendees. (2018, Bryant University. Meeting theme: *Novel Research in Energy Topics, and Transformative Methods for Teaching Undergraduate Students About Energy Concepts*. Chairs: Dawn Meredith (U. New Hampshire) and Nancy Ruzyck (U. Florida).)
  - Co-Chair, with Shane Larson (Northwestern U.), elected by series attendees. (2020. Meeting theme: *Climate Physics*.) [*n.b.*: series canceled by GRF following 2018 meeting.]
  - Discussant, session on "Involving Undergraduates in Cutting Edge Biophysics Research and its Implications for Instruction" (2014, Mount Holyoke College. Meeting theme: *The Complex Intersection of Biology and Physics*.)
- **American Physical Society**
  - Member (2005–present).
  - Selection Committee for APS "Reichert Award" (2022).
  - Current units: *Forum on Education, Forum on Physics & Society, Forum on Outreach & Engaging the Public, Topical Group on Physics Education Research, New England Section*.
  - Meeting attendee: MM* 2012 (Boston); MM 2014 (Denver); MM 2016 (Baltimore); MM 2019 (Boston); MM 2022 (Chicago, remote).
- **American Association for the Advancement of Science**, Member (2018–present).
- **Sigma Xi** scientific research society, Associate Member (inactive, 1999–present).

Institutional Service

- **MIT RIC7 Followup Task Force** on "Career Support for Instructional Staff", member (2023–2025).
- **MIT Medium Radio Telescope Operations Committee**, member representing Dept. of Physics (2023–present).
- **MIT Physics Department Head Search Committee**, member, appointed by MIT Dean of Science (Summer 2022).
- **Physics@MIT Annual Journal**, editorial board member (2017–2019).
- **MIT Senior House Turnaround Team**, member, appointed by MIT Chancellor, Community Subcommittee (2016–2017).
- **MIT Physics Flexible Program Coordinator**, providing detailed and thoughtful curriculum and career advising for majority of MIT physics majors (about 70 students/year) as official signatory on graduation requirement plans. (2009–present)
- **MIT Physics Graduate Teaching Assistant Coordinator**, about 35 students/semester (2007–2009).

*MM = *APS March Meeting*

- **MIT Physics Education Committee**, member *ex officio*. Attended regular meetings; prepared and presented various internal reports on the structure and enrollment of the physics major, communication-intensive subjects, and the lab courses as requested by the Committee chair; served on or co-chaired *ad hoc* task forces as requested by the Committee chair. (2007–present)

External Reviewer

- **Cambridge Assessment International Education**, Review of 2022 Physics A-Level & AS-Level syllabus and exam content (Summer 2018).
- **Book reviewer**, pre-publication technical review.
  - *How We Came to Know the Cosmos, Vols. 1 & 2*, by Helen Klus. The Star Garden (December 3, 2017).
  - *Ballparking: Practical Math for Impractical Sports Questions*, by Aaron Santos. Running Press (May 1, 2012).
- **Poster contest judge**
  - *2012* ΣΠΣ *Quadrennial Physics Congress* (Orlando, FL).
  - MIT Society of Physics Students poster contest (2009–2012).
- **Journal referee**: Physical Review Letters; Physical Review D; Physical Review Physics Education Research; Physics Letters B; Journal of High Energy Physics; General Relativity and Gravitation; Europhysics Letters; Nature; Entropy; International Journal of Thermophysics; American Journal of Physics.
- **Candidate/promotion reviewer**: Brigham Young University; Freiburg Institute for Advanced Studies; Lahore University of Management Sciences.

Other Professional Service and Public Outreach

- **Boy Scouts of America**, registered adult leader.
  - Nuclear Science merit badge counselor. Mayflower Council (2017–2020).
  - Assistant Scoutmaster, trained. Troop 101, Marshfield, MA (2016–2022).
- **Climate Change National Forum**, science commentator (2014–2016) http://climatechangenationalforum.org.
- **Furnace Brook Middle School Climate Science Symposium,** organizer and expert science presenter. Marshfield (MA) Public Schools (2014–2019).
- **Coastal Adaptation Advisory Committee**, municipal government technical advisory committee, by appointment of the Board of Selectmen, Town of Marshfield, Massachusetts.
  - Committee member and secretary (2013–2018).
  - Lead data-driven development of Beach Management Plan for best-practice operations of municipal resources.

Theses & student projects supervised or co-supervised

[1] Jorian Benke, Eric Cusson, Teo Lara, Diego Rivera, Ben Volokh, "Project Lab in Radio Astrophysics", MIT Subject 8.18 *Research Problems in Undergraduate Physics*, January 2025. (Instructor.)

A group of five physics undergraduates propose, execute, analyze, and present an original project in radio astrophysics, hunting for signals from the Crab Pulsar, learning skills in project management, team leadership, computational methods, radio hardware, and astrophysics. With additional guidance from Prof. J. Hewitt, Prof. K. Masui, and Dr. A. Levine.

[2] Lulu Russell, "Special course on hands-on physics and mechanical fabrication skills", MIT Subject 8.18 *Research Problems in Undergraduate Physics*, Spring 2022. (Instructor.)

An experimental curriculum in mechanical fabrication techniques aimed at undergradatuate students is developed and tested.

[3] Bahrudin Trbalic, "Implementation of the Fizeau aether drag experiment for an Undergraduate Physics Laboratory", S.B. thesis in physics, MIT, May 2020. (Supervisor. Co-supervisor: J. Formaggio.)

The classic Fizeau apparatus is adapted for the modern advanced laboratory teaching setting, allowing for an interferometric method of distinguishing the relativistic and Galilean models of velocity addition.

[4] Karia Dibert and Daniel Sheen, "Radome Renovation and Adaptation for 21cm Astrophysics", Undergraduate research in physics, MIT, Spring 2018. (Supervisor)

The 6-meter scanning radio dish in the large radome atop MIT's Bldg 54 is rehabilitated into a working condition, requiring extensive mechanical work and a complete rebuild of the RF instrumentation chain based on a modern software-defined radio architecture.

[5] John Peurifoy, "MIT-Imperial College Research Exchange: Experimental Implementation of Permanent Magnetic Optical Traps", Undergraduate research in physics, Imperial College, London, Summer 2017. (MIT-side co-supervisor)

An attempt is made to construct a magnetic ion trap using permanent magnets at room temperature rather than cryogenically cooled superconducting electromagnets. I served as the MIT supervisor-of-record for this project, which was performed at Imperial College.

[6] Rodolfo Garcia, "Analyzing Junior Lab Evaluation Data", Undergraduate research in physics, MIT, Spring 2017. (Supervisor)

A framework is developed for analyzing a growing backlog of data regarding student learning experiences in the MIT Physics Junior Lab.

[7] William Caruso and Chandler Squires, "Software Modeling of Infectious Diseases", Undergraduate research in physics, MIT, Summer 2015. (Supervisor)

A web-service software tool named "OFFlMaker" is designed, built, and deployed on the web as an implementation of the ideas in the OFFl modeling framework developed by Ogbunugafor & Robinson [14].

[8] Mateo Williams, "Diffusion Cloud Chamber for Educational and Art Demonstration", Undergraduate research in physics, MIT, Spring 2015. (Supervisor)

A novel implementation of a cloud chamber (visualizing the tracks of energetic particles in real space and time) is designed and built for installation in a temporary student art exhibit. While standard cloud chambers for public exhibition operate at atmospheric pressure with a temperature gradient provided by dry ice to created supersaturated vapor clouds, the present design uses a a pulsed vacuum and a temperate gradient supplied by a warming plate to achieve supersaturation.

[9] Christopher Sarabalis, "Measuring acoustic fields in an optical trap", S.B. thesis in physics, MIT, June 2014. (Supervisor. Co-supervisor: J. Paradisio.) http://hdl.handle.net/1721.1/92690

A small phased array of acoustic transducers on a microscope slide is used in a first step towards acoustic techniques for holographic micromanipulation of small objects. Measurements of the resulting forces are made using optical tweezers.

[10] Antony Speranza, "Stochastic congruence equations for spacetime fluctuations", S.B. thesis in physics, MIT, June 2012. (Supervisor) http://hdl.handle.net/1721.1/78491

The consequences of treating general relativity as the thermodynamic limit of some underlying microscopic theory are considered by examining the effects of non-equilibrium fluctuations in the microscopic theory as a stochastic noise contribution to general relativity.

[11] Achilleas Porfyriadis, "Boundary Conditions, Effective Action, and Virasoro Algebra for AdS_3", S.B. thesis in physics, MIT, June 2010. (Co-supervisor. Primary supervisor: F. Wilczek.) http://hdl.handle.net/1721.1/61262

A complete formalism is presented for constructing an effective action of small spacetime excitations around approximate solutions of general relativity and examining the asymptotic symmetries of spacetimes via this effective action.

Publications, preprints, and theses

[12] Aaron Kessler and Sean P. Robinson, "Promoting Learning Goals in an Advanced Physics Laboratory via Student-Centered Learning: A Case Study Using the MITx Residential Platform", *Routledge Handbook on Student-Centered Learning and Instruction in Higher Education*, eds. Sabine Hoidnand Manja and Klemenčič, Routledge/Taylor & Francis: Abingdon, Oxfordshire (2020).

A case study of the curriculum transformation in Junior Lab, focusing on the use of the MITx Residential software platform to enable a student-centered learning environment. An analysis of click-level data from MITx reveals strong student engagement in online preparatory materials before coming to the lab.

[13] Duncan C. Wheeler, Emma Bingham, Michael Winer, Janet M. Conrad, and Sean P. Robinson, "Observation of relativistic corrections to Moseley's law at high atomic number", [arXiv:1809.10480].

An experiment appropriate to an advanced teaching laboratory for measuring relativistic deviations from Mosely's law is presented along with comparisons to competing theoretical predictions.

[14] C. Brandon Ogbunugafor and Sean P. Robinson, "OFFl models: novel schema for dynamical modeling of biological systems", PLoS ONE 11(6): e0156844 (2016), [arXiv:1604.01674].

A novel but intuitive graphical schema for modeling complex biological and environmental systems is presented, named "OFFl" for its ability to automatically generate "Ordinary differential equations from Formalized Flow diagrams" without any mathematical tinkering on the part of the modeler. The schema is described as being useful for students and practitioners in the biological, medical, and public health fields who face problems for which mathematical modeling would be helpful, but for whom mathematical intuition and training tends to be lacking.

[15] Sean P. Robinson, Gunther Roland, Charles Bosse, and Evan Zayas, "Effectiveness of flipped classroom techniques in an advanced laboratory physics course", *2015 Conference on Laboratory Instruction Beyond the First Year of College Proceedings*, pp. 92-95, DOI:10.1119/bfy.2015.pr.023.

Data of several types on the learning outcomes and program goals for students in the MIT Physics Junior Lab are compared across a five year period which included an intervention of flipped classroom techniques.

[16] S. P. Robinson, " 'So what did you measure?' Henry W. Kendall and Physics Junior Lab", MIT Physics Annual 2010.

A description is given of the influence of Professor Henry Kendall on the development of laboratory physics teaching at MIT, a short professional biography of this aspect of his otherwise well-documented career.

[17] S. Das, S. P. Robinson, and E. C. Vagenas, "Gravitational anomalies: a recipe for Hawking radiation", Int. J. Mod. Phys. D **17**, 533 (2008), [arXiv:0705.2233]. *Received Honorable Mention in the 2007 Gravity Research Foundation Essay Contest.*
Status and developments of the Robinson-Wilczek anomaly method are reviewed.

[18] S. P. Robinson, "Normalization conventions for Newton's constant and the Planck scale in arbitrary spacetime dimension", [arXiv:gr-qc/0609060].
The relationship between the coupling coefficients of general relativity and its Newtonian limit are calculated in arbitrary spacetime dimension. A dimension-dependent factor which is often neglected in the literature is elucidated.

[19] S. P. Robinson and F. Wilczek, "Gravitational Correction to Running of Gauge Couplings", Phys.Rev.Lett. **96** 231601 (2006), [arXiv:hep-th/0509050], MIT-CTP-3617.
One-loop graviton corrections to the running of gauge couplings are calculated. Gravity appears to render all gauge couplings asymptotically free.

[20] S. P. Robinson and F. Wilczek, "Relationship Between Hawking Radiation and Gravitational Anomalies", Phys.Rev.Lett. **95**, 011303 (2005), [arXiv:gr-qc/0502074], MIT-CTP-3561.
Hawking radiation is shown to be a requirement for maintaining general covariance in the effective quantum theory of fields living around a black hole.

[21] Sean Patrick Robinson, "Two Quantum Effects in the Theory of Gravitation", MIT Ph.D. Thesis in Physics, June 2005. http://hdl.handle.net/1721.1/32310
Two small steps from classical to quantum gravity are explored: quantum field theory in curved spacetime and quantum general relativity as an effective field theory. Within the former, the effective theory of fields near a black hole is studied, while in the latter the effects of quantum gravity on the renormalization of Yang-Mills couplings are calculated.

[22] Sean Patrick Robinson, "Single Function Call Probabilistic Quantum Algorithm for Searching an Ordered List", MIT S.B. Thesis in Physics, June 1999.
A procedure is described for finding a marked item on a sorted list of N items using a quantum computer. The procedure succeeds with probability scaling as $\ln(N)/N$ after a single query to the list. The best classical procedure yields only $2/N$.

Presentations, posters, events, *etc.*

Poster Randolph S. Peterson (presenter), Sean Robinson, John Wilson, "Measurement of Alpha Particle Energies and Half-lives in Air", *AAPT Summer Meeting 2025* (Washington, DC).

Invited Talk Sean P. Robinson, "Understanding the Role of Physics Labs in the Curriculum", *AAPT New England Section Spring Meeting 2025* (MIT).

Invited Talk Sean P. Robinson, "Role of Advanced Laboratory Teaching in a Research University's Undergraduate Physics Curriculum", *University of Delaware Physics Colloquium*, November 2024 (Newark, DE).

Session Organizer Sean P. Robinson, "Session IK: Remembering Charlie Holbrow", *AAPT Summer Meeting 2024* (Boston, MA).

Served as organizer and moderator for special memorial session honoring the legacy of former AAPT President and ExO, Charles H. Holbrow (1935–2023).

Contributed Talk Sean P. Robinson, "First results from a new student-operated radio astrophysics facility at MIT", *AAPT Summer Meeting 2024* (Boston, MA).

Poster Sean P. Robinson (presenter), Daniel Sheen, Oris Salviano Neto, Aaron Pilarcik, "First results from a new student-operated radio astrophysics facility at MIT", *AAPT Summer Meeting 2024* (Boston, MA).

Vendor/Presenter Sean P. Robinson, *et al.* (MIT Physics Education Group), "MIT Department of Physics", *AAPT Summer Meeting 2024* (Boston, MA).

Invited Workshop Sean Robinson, Peter Dourmashkin, Michelle Tomasik, Mohamed Abdelhafez, Shams El-Adawy, "TEAL Blended Learning Workshop", *AAPT Summer Meeting 2024* (Boston, MA).

Contributed Talk Sean P. Robinson, "Role of advanced laboratory in a research university's undergraduate physics curriculum", *AAPT Winter Meeting 2024* (New Orleans, LA).

Poster S.P. Robinson (presenter), Aaron Pilarcik, "Cosmic Ray Muon Detection in a Simple Hand-Held Device", *AAPT Winter Meeting 2024* (New Orleans, LA).

Contributed Talk Sean P. Robinson, "ALPhA Slam: How do you staff your physics teaching labs? The physics of human resources & vice versa", *ALPhA New England Regional Meeting 2022* (Bridgewater, MA).

Introductory Remarks Sean P. Robinson, "Teaching Advanced Lab? ALPhA is here to help", *ALPhA New England Regional Meeting 2022* (Bridgewater, MA).

Invited Talk Sean P. Robinson, "Challenges & opportunities in physics advanced laboratory instruction", *APS March Meeting 2022* (virtual, Chicago).
Note: talk at special invited session in honor of the recipient of the 2022 Jonathan F. Reichert & Barbara Wolff-Reichert Award for Excellence in Advanced Laboratory Instruction *of the APS, which was myself.*

Contributed Talk Gladys Vélez Caicedo (presenter), Andres Reyna, and Sean P. Robinson, "Deployment of a Low-Cost Muon Detector as a Remote Experiment", *AAPT Summer Meeting 2021* (virtual).

Contributed Talk Andres Reyna (presenter), Gladys Velez Caicedo, and Sean P. Robinson, "Application of Red Pitaya STEMLab to Remote Advanced Laboratory Teaching", *AAPT Summer Meeting 2021* (virtual).

Invited Panel Talk Sean P. Robinson (presenter) and Christoph Paus, "Introductory Undergraduate Course on Experimental Physics Apparatus and Techniques" in panel session "The role of technical competencies in physics undergraduate education", *AAPT Winter Meeting 2020* (Orlando, FL).

Invited Talk Sean P. Robinson, "Structure and Interpretation of MIT Physics 'Junior Lab'", *Workshop on Undergraduate Physics Laboratory in the 21st Century*, May 2019 (Columbia University).

Contributed Talk Emma Bingham (presenter), Duncan C. Wheeler, Michael Winer, Sean P. Robinson, and Janet M. Conrad, "Observations of relativistic corrections to Moseley's law at high atomic number", *APS March Meeting 2019* (Boston, MA).

Invited Talk Sean P. Robinson, "Progress towards new experimental techniques course for second-year physics majors", *AAPT Summer Meeting 2017* (Cincinnati, OH).

Invited Talk Sean P. Robinson, "Student Projects in MIT Physics Junior Lab, Spring 2017", *ALPhA New England Regional Meeting*, June 2017 (Amherst College).

Contributed Talk Sean P. Robinson, "ALPhA Slam: Comments on Python and other issues in labs", *ALPhA New England Regional Meeting*, June 2017 (Amherst College).

Invited Panel Member "Maximizing Benefit from Sea Level Rise Initiatives: Complementary Projects, Economies of Scale, and How to Promote Coordinated Inter-municipal or Regional Climate Change Initiatives", *South Shore Climate Change And Sea Level Rise Symposium*, December 2016 (Norwell, MA).

Contributed Talk Sean P. Robinson, "Assignment Sequences for Experimental Skill Development in Physics Advanced Lab", *AAPT Summer Meeting 2016* (Sacramento, CA).

Poster Sean P. Robinson and Charles Bosse. "Advanced Laboratory Experiment: Relativistic Dynamics of the Electron". *Gordon Research Conference on Physics Research and Education — Relativity*, June 2016 (Salve Regina College).

Poster Sean P. Robinson (co-presenter), Gunther Roland, Charles Bosse (co-presenter), and Evan Zayas, "Effectiveness of flipped classroom techniques in an advanced laboratory physics course", *Conference on Laboratory Instruction Beyond the First Year of College (BFY2)*, July 2015 (College Park, MD).

Invited Panel Member Climate Change National Forum virtual session on "Coastal Preparedness", *Earth Day Texas 2015*.

Invited Talk Sean P. Robinson, "Using instructional laboratories and research experiences in physics to build better people", Reichert Award Session, *APS March Meeting 2014* (Denver, CO).

Contributed Talk Sean P. Robinson,"MOOC Tools to Enhance Professional Development in the Advanced Lab", *AAPT Winter Meeting 2014* (Orlando, FL).

Poster S.P. Robinson (presenter), G. Roland, C. Bosse, C. Sarabalis, "MOOCs in the Physics Lab? Reports from the Front: Fall 2013 experiment with edX in the MIT Physics Junior Lab", *AAPT Winter Meeting 2014* (Orlando, FL).

Poster C. Bosse (presenter), G. Roland, S. Robinson, A. Strelnikov, C. Sarabalis, E. Ng, A. Villar,"Supporting an Advanced Lab Course Using a Massive Online Course Platform" *AAPT Summer Meeting 2013* (Portland, OR).

Invited Panel Talk Sean P. Robinson, "Learning Goals in Advanced Lab — MIT Physics Junior Lab: Structure & Pedagogy" *AAPT Winter Meeting 2013* (New Orleans, LA).

Vendor/Presenter "MIT Department of Physics", *2012* ΣΠΣ *Quadrennial Physics Congress*, November 2012 (Orlando, FL).

Invited Workshop Sean P. Robinson, "Arduino: PID-controlled thermostat; or, how to do things with Arduino without ever becoming an expert", *Conference on Laboratory Instruction Beyond the First Year of College*, July 2012 (Philadelphia, PA).

Poster C. Bosse, S. Robinson, "Physics Advanced Lab Structure and Planning", *Conference on Laboratory Instruction Beyond the First Year of College*, July 2012 (Philadelphia, PA).

Poster Sean P. Robinson, "What is the purpose of physics Advanced Lab? Insights from history, and comparison to a local case study, but no answers", *Gordon Research Conference: Physics Research and Education — Experimental Research and Labs in Physics Education*, June 2010 (Mount Holyoke College).

Thesis Defense Sean P. Robinson, "Two Quantum Effects in the Theory of Gravitation", May 2005 (Center for Theoretical Physics, MIT).

Seminar Sean P. Robinson, "One-loop graviton corrections to QCD Beta Functions", *Friday Lunch Club*, Spring 2005 (Center for Theoretical Physics, MIT).

Seminar Sean P. Robinson, "Hawking Radiation and Gravitational Anomalies", *Friday Lunch Club*, Fall 2003 (Center for Theoretical Physics, MIT).

Seminar Sean P. Robinson, "Domain Wall Fermions", *Friday Lunch Club*, Fall 2002 (Center for Theoretical Physics, MIT).

Poster C. Wang, K. Paularena, J. Richardson, J. Belcher, S. Robinson, "Wavelet Analysis of Solar Wind Shocks", *American Geophysical Union Spring Meeting 1999* (Boston, MA).

Internal reports & presentations

Invited Panel Member Aaron Kessler (chair), with Paola Rebusco, Cory Romanov, Maria Khotimsky, McKenzie Dinesen, Sean Robinson. "Moving Forward Together". *MIT Festival of Learning*, January 2025. [https://youtu.be/w2Qe5GpFMB4]

Invited Panel Talk Sean P. Robinson, "xTalk Panel: Using Digital Technologies to Refresh On-Campus Courses Over Time", *MIT Open Learning xTalk Series*, October 2022. [https://youtu.be/KrbrPltzXjc]

Invited Talk Sean P. Robinson, "Student engagement with online content in Junior Lab: a hands-on advanced experimental physics course", *MITx Significant Interest Group*, December 2019.

Poster Sean P. Robinson, Gunther Roland, Charles Bosse, Evan Zayas, "Effectiveness of flipped classroom techniques in an advanced laboratory physics course", *MIT Festival of Learning*, February 2017.

Invited Talk Sean P. Robinson, "Physics Career Options, Education Research, and Epidemiology of the Zombie Apocalypse", *MIT Physics IAP Lecture Series*, January 2017.

Invited Talk Sean P. Robinson, "edX-enabled flipped classroom techniques in Physics Junior Lab", *MIT DUE Visiting Committee Panel Discussion*, March 2016.

Invited Talk Sean P. Robinson, "Innovations in Progress: 8.13x", *MITx Significant Interest Group*, May 2014.

White Paper Junior Lab staff and advisors (prepared by Sean P. Robinson), "Planning omnibus for 8.14 remediation", August 2011.

Internal grants received

Proposal (Funded) Long Ju, Sean P. Robinson, Randolph S. Peterson, "An Educational Module for Creating Modern Electronics in the Undergraduate STEM Laboratory Program", *Jameel World Education Lab Innovation Grant* (2024–2025).

Proposal (Funded) Sean P. Robinson, "Curriculum reorganization for Physics Junior Lab using Canvas resources", *Canvas Innovation Fund* (2024).

Proposal (Funded) Sean P. Robinson, Gunther Roland , "Digital Learning in MIT Junior Lab" *d'Arbeloff Fund for Excellence in Education* (2013 – 2016).

Proposal (Funded) Gunther Roland, Sean P. Robinson, Nergis Mavalvala, David Litster, "Exploring Digital Learning in MIT Junior Lab", *MIT Office of Digital Learning* (2013).

Teaching Statement

I am a science teacher. My teaching focuses on the professional development of students as scientific thinkers, practitioners, and, eventually, as colleagues and peers. Over the course of my career, I have worked in multiple educational roles, often simultaneously:

- as an instructor, mentor, and advisor, working directly with students, mostly in the setting of advanced physics laboratory education;
- as a curriculum designer and implementer, again mostly in the physics laboratory context;
- and as an organizational leader at both the institutional level and in the (inter)national community of physics education professionals.

Having my work in each of these categories recognized by my peers has been a great honor, most notably with the American Physical Society's *Reichert Award for Excellence in Advanced Laboratory Instruction* in 2022, where I was cited both for "leading and helping to develop Junior Lab, MIT's advanced physics laboratory" and for "pedagogical excellence that extends to the broader advanced physics laboratory community". (I also routinely score near the top of student evaluation scales.)

In Junior Lab, we have implemented a successful curriculum which utilizes laboratory work as a medium to build students into physicists. We teach technical writing and presentation skills, data analysis, hardware troubleshooting, collaboration skills, scientific argumentation, common instrumentation, scientific programming, and, of course, experimental modern physics. I have also worked in (and enjoyed) multiple education environments outside of formal academic lab instruction — mentoring and research advising, informal science outreach with school and youth groups, public sector advising, astronomical field work, novel classroom formats (such as TEAL physics studio), and even athletic coaching — but I will focus in this statement on my work in formal higher education, where I believe I can claim a degree of expertise, not just experience.

Theory of teaching and learning

My approach to teaching is grounded both in the science of teaching and learning and in the lessons of prior education movements. For theory, my teaching fundamentally uses the constructivist approach, treating learning as a process that happens in the mind of the student. This leaves the teacher's role as setting up and managing a learning environment (both sensory and social, and notably including the course materials and classroom activities) that promotes learning when students interact with it. As such, my teaching philosophy generally follows the broad influence of Piaget and later constructivist developments from Karplus and Vygotsky [1]. My classroom technique — both my own technique, and in my advising of new physics lab instructors — carries strong influence from the framework of cognitive apprenticeship [2], which, again, is rooted in constructivism. As an instructor, I find myself most naturally in the "coaching" and "scaffolding" methods of that framework, but all of the methods are represented in my curriculum design work. Scaffolding concerns and the zone of proximal development [1] also set the order and pacing of Junior Lab's course design.

As my teaching focuses on the professional development of students as scientists (that is, producing learners who identify as "physicists" instead of merely as "physics students"), I also incorporate expert-novice, identity construction, and community-of-practice frameworks in my designs. This promotes learner agency and self-efficacy to build intrinsic motivation — moving students away from external motivators, like grades — a consistent research-validated predictor of positive learning outcomes which is naturally accessible in

lab work via project-based learning. The lab environment, with its array of strange apparatus, is also rich in novel sensory inputs, and our students arrive in the classroom context already burdened by external academic, physical, social, and cultural sources [1, 3] that require cognitive resources to navigate and prioritize — including, in the case of Junior Lab, the class's stress-laden reputation in MIT culture — so the framework of cognitive load is critical for tracking the novice student's ability to negotiate the learning environment.

Luckily, my career as a physics educator began shortly after physics education research (PER) matured into a fully robust field with its own evidence-based frameworks which I can both draw on as a resource and, to a lesser extent, participate in via my own scholarship. I especially look to the so-called resources framework as articulated by Redish [4] and others: a PER-centered modern synthesis of the preceding century of work in education science. In my specific subfield of laboratory instruction, the past decade has generated several particularly high quality PER studies whose conclusions I have incorporated into my own teaching and curriculum design efforts. Specifically, my work is strongly informed by that of Lewandowski [5, 6, 7, 8, 9], Holmes [10, 11, 12], and their many collaborators.

While PER has brought a level of experimental rigor to physics education, I also draw influence from the industrial-era education reformers in the decades before Piaget brought education into the realm of psychological science — Horace Mann, William Barton Rogers, John Dewey, and Maria Montessori — who, in varying degrees, observed and promoted the power of experiential learning by active, hands-on practice and saw education as a public service for the advancement of democratic ideals. While addressing the problems of their own times, many of their writings speak with clarity and relevance to the American education system today. When designing my courses from the systems level downwards, I often find inspiration in their work.

Curriculum design and pedagogy

Whether designing individual class activities or overhauling an entire academic program, my primary strategy is so-called backwards design, in which we start from the learning goals and then design backwards into figuring out what content needs to be taught to reach those goals, by which types of lessons and assessments, on what phasing and pacing, at the cost of what resources in terms of staff, space, and materials. I then cycle back through the relevant educational theory for guidance on each step throughout the design process. This approach has been consistently successful on design projects large and small, with the additional caveat that designing course-level structures benefits from applying the principles of student-centered curriculum design and from attention to the sociocultural motivations and academic background of the intended audience, which can vary greatly depending on where the course sits in an overall academic program. How, then, to determine the learning goals to design back from?

My first approach is to understand the design problem as existing in a hierarchy of educational contexts, with the design at each level setting goals for the next level down. At the top level is the mission goal of the institution within society, down through the academic program — say, a physics major or a general education program — to the individual course, and then the elements of the course design, possibly with an intermediate layer of unit goals. For a research university like MIT, that top-level mission is to create, curate, and disseminate scholarly knowledge for the betterment of society — by the means of operating a school. Working backwards from this institutional goal to an advanced physics lab course like Junior Lab, for example, focuses the course goals on professional skill building and identity formation within the intermediate context of the physics academic program's goal of creating people who think like physicists, with the skills and knowledge necessary to apply that thinking to that world.

For a second approach to goal-setting, Bloom's taxonomy [13, 14] shows the utility of classifying learning goals. For the narrow context of physics education, I have developed a

three-level coarse-graining of Bloom's more general six-level cognitive domain: (1) "learn *about* physics", (2) "learn *how to do* physics", and (3) "learn *how to be* a physicist". As a lab instructor, I focus on the third category, but all are necessary in an academic program, and all tend to be present to some degree in every course or assignment. This simple classification scheme has proven useful for quick decision-making on design questions, even for improvised lessons which are common in lab settings.

Another critical element in my goal-setting strategy is to leverage the broader community of professional peers who are often wrestling with the same questions and have generated thorough reports addressing them. I routinely consult the *AAPT Recommendations on Lab Curriculum* [15] and the J-TUPP *Phys21* report [16] in my work.

My other design strategy besides backwards design is working on design teams, ideally including students. A team-based design effort both shares workload and adds diverse perspectives, mitigating problems like the expert blind spot phenomenon [17]. Critically, it can be used to engage community stakeholders (students and faculty from the affected program) and build a sense of shared ownership to facilitate acceptance of the eventual product. I also prefer to design *for* a teaching team who can model professional collaboration in the classroom, building a more authentic science learning environment. This raises the concern that the curriculum needs to executable by the expected teaching team — that is, not myself — again heightening the value of cognitive diversity on the design team.

Physics education as a professional community

From the national level down to the classroom, education requires coordinated action by teams of people, so organizational leadership can be as impactful to outcomes as classroom teaching. At the department and institutional level, I have coauthored numerous task force reports that now live on in the structure of academic programs. At the national level, service to the community of physics educators through the AAPT and ALPhA professional societies has helped me affect the field as a whole. As the elected Treasurer of ALPhA, I lead the long effort to incorporate the organization, write bylaws, and establish sound financial practices, amplifying its already out-sized impact on the field.

A key part of my professional growth has been active engagement in the scholarly community of physics educators beyond MIT: harvesting the collective expertise of the field for the benefit of my home institution, contributing back into the field through scholarship and service, and leveraging the community to expand the impact of my efforts to many more institutions' students.

Education professionals at research-focused institutions face career challenges in having their work recognized as legitimate scholarship. (Loosely paraphrasing Nobel laureate Patrick Blackett [18], progress in some sectors of physics is measured in publications, while for others it is measured in "implementations". In my experience, educational contributions to physics often fall in this second category, where scholarly impact on the field can be significant, but is seldom propagated in citable form.) My recent focus has been building the MIT Physics Education Group as "the home for physicists at MIT with a professional specialization in education", attempting to innovate hiring and promotion practices for this sector while growing an internal community of educators to support each other's work.

When my career has eventually run its course, I wonder if I will regard my professional successes more through the impact on the world of the many extraordinary students I have personally taught at MIT, or through the impact of the systems I have developed and organizations I have helped build. At the current midpoint of my career, I have been recognized by the community for achievements in both aspects of education, and I hope I can continue to contribute to the field in these ways for the half left to come.

[1] Lev S. Vygotsky, *Mind in society: The development of higher psychological processes*, (Harvard University Press, 1978).

[2] Allan Collins, John Seely Brown, Susan E. Newman, "Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics (Technical Report No. 403)", UIUC Center for the Study of Reading; Bolt, Beranek and Newman, Inc. (1987).

[3] Abraham H. Maslow, "A theory of human motivation", Psychological Review. **50** (4): 370–396 (1943).

[4] Edward F. Redish, "Oersted Lecture 2013: How should we think about how our students think?", Am. J. Phys. **82** (6): 537–551 (2014).

[5] Benjamin M. Zwickl, Dehui Hu, Noah Finkelstein, Heather J. Lewandowski, "The process of transforming an advanced lab course: Goals, curriculum, and assessments", Am. J. Phys. **81**, 63–70 (2013).

[6] Benjamin M. Zwickl, Dehui Hu, Noah Finkelstein, Heather J. Lewandowski, "Model-based reasoning in the physics laboratory: Framework and initial results", Phys. Rev. ST Phys. Educ. Res. **11**, 020113 (2015).

[7] Bethany R. Wilcox, Heather J. Lewandowski, "Students' epistemologies about experimental physics: Validating the Colorado Learning Attitudes about Science Survey for experimental physics", Phys. Rev. Phys. Educ. Res. **12**, 010123 (2016).

[8] Bethany R. Wilcox, Heather J. Lewandowski, "Open-ended versus guided laboratory activities: Impact on students' beliefs about experimental physics", Phys. Rev. Phys. Educ. Res. **12**, 020132 (2016).

[9] Bethany R. Wilcox, Heather J. Lewandowski, "Developing skills versus reinforcing concepts in physics labs: Insight from a survey of students' beliefs about experimental physics", Phys. Rev. Phys. Educ. Res. **13**, 010108 (2017).

[10] Carl Wieman, Natasha G. Holmes, "Measuring the impact of an instructional laboratory on the learning of introductory physics", Am. J. Phys. **83** (11): 972–978 (2015).

[11] Natasha G. Holmes, Jack Olsen, James L. Thomas, Carl E. Wieman, "Value added or misattributed? A multi-institution study on the educational benefit of labs for reinforcing physics content", Phys. Rev. Phys. Educ. Res. **13**, 010129 (2017).

[12] Natasha G. Holmes, Carl E. Wieman, "Introductory physics labs: We can do better", Physics Today **71** (1), 38–45 (2018).

[13] Benjamin S. Bloom (Ed.), *Taxonomy of Educational Objectives: The Classification of Educational Goals*, 1st Edition, (David McKay Company, New York, 1956).

[14] Lorin W. Anderson, David R. Krathwohl (Eds.), *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*, (Addison Wesley Longman, Inc., New York, 2001).

[15] Joseph Kozminski, *et. al.*, "AAPT recommendations for the undergraduate physics laboratory curriculum", American Association of Physics Teachers (2014).

[16] Joint Task Force on Undergraduate Physics Programs (Paula Heron and Laurie McNeil, Co-chairs), "Phys21: Preparing Physics Students for 21st-Century Careers", American Physical Society (2016).

[17] Mitchell J. Nathan, Martha W. Alibali, Kenneth R. Koedinger, "Expert Blind Spot: When Content Knowledge & Pedagogical Content Knowledge Collide (Technical Report 00-05)", UCBoulder Institute of Cognitive Science (2000).

[18] Patrick M.S. Blackett, "*We experimentalists are not like theorists: the originality of an idea is not for being printed in a paper, but for being shown in the implementation of an original experiment.* London 1962", quoted on commemorative plaque at entrance of the EMFCSC Blackett Institute, Erice, Sicily.