

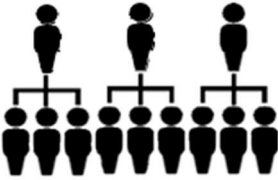
Supplemental Digital Appendix 1

Complete Case Examples of Medical Education Labs and Larger Research Entities

To provide case examples, each of our authors described several defining characteristics about their education research teams: the name of their research unit, organizational structure, sponsoring institution, primary research emphasis, primary funding mechanism, need for institutional support, readiness to start the research unit, trainee impact, challenges to success, and/or advice for prospective education researchers. We collated these case examples below according to the organizational structure of their research units.

Single Principal Labs 	These labs are usually run by a single senior scientist. Most akin to basic science research labs, these rely on a linchpin PI who maintains the infrastructure to support trainees and students within the lab. The following is an example of one such lab.
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PRIME Collective. The Burkhardt Policy analysis, Research, and Innovation in Medical Education (PRIME) Collective was formed at the University of Michigan in 2020 by a single PI who had the goal of creating a community of medical educators with a specific research agenda: “To leverage the power of medical and professional education for the greater public good.” The lab stemmed from a desire to better align the PI’s research activities with his overall research agenda, as well as to increase his visibility for potential mentees and new collaborators. The decision to initially coalesce around a single investigator was one of practicality. First, the PI was committed to the lab concept as change leader in his institution and sought out specific coaching and literature on best practices around the creation of more traditional lab systems. Second, the PI was the education researcher with most of the external and internal funding within his department, and this funding provided him with more opportunity to recruit junior researchers that were interested in learning about medical education research. Finally, the PI was the only medical education researcher in the department with a tenure-track appointment, making the creation of a lab structure desirable for use in his future promotion packet. The PRIME Collective was created with the plan for distributed agency amongst all participatory investigators but with oversight by the PI. This was an intentional design choice that incorporated several components of a more traditional lab structure and the PI’s commitment to a positivist leadership approach. Specific lab management processes were created with the goal of improved inter-researcher communication, streamlining of leader and mentorship activities, and structures that were recognizable to researchers in other fields for purposes of funding and promotional activities. The PRIME Collective currently includes faculty members, fellows, residents, medical students, and undergraduate students as co-investigators, with most members drawn from the PI’s primary and secondary department affiliations, as well as contributors from outside the medical school.

Multiple Principal Labs 	These labs are usually run by a group of senior scientists who share a common research agenda. This type of lab allows for a shared accountability and increased financial resilience, since each PI within the system can initiate and hold grants. The following are two examples of multi-PI labs.
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The PEARL. Based at Stanford University, the Precision Education and Assessment Research Lab (PEARL) was established in the Department of Emergency Medicine in 2019. The PEARL is directed by a team of three researchers with unique skills and backgrounds that complement one another. The breadth of experience of the directors allows for mentorship of a variety of research interests among the trainees in the lab, which includes medical education scholarship fellows, medical simulation fellows, medical students, and undergraduate students. The mission of The PEARL is to “define precision in medical education by studying the best ways to individualize training for physicians, to optimize assessment methods to promote learning, and to leverage technology to reimagine health professions education.” The primary lines of investigation in The PEARL coalesce around the concepts of precision education and assessment, providing a distinctive theme that distinguishes the lab and its body of work. The development of new technology needed to generate big data in medical education is a priority research outcome, as is the application of machine learning algorithms for predictive learning analytics. The PEARL hosts a weekly conference series in medical education for faculty collaborators and trainees, as well as a weekly research works-in-progress session. A lab manager is funded by an extramural grant and by the sponsoring department. Additional administrative support is made available by the department, as needed. The lab functions without dedicated physical space, using department offices for lab meetings and conferences.

The TIER Lab. The Texas Innovation and Educational Research (TIER) Lab was formed in 2021 in the Department of Emergency Medicine at McGovern Medical School with the goal of developing, implementing, and measuring the impact of innovative medical education tools. The TIER lab aims to drive engagement, knowledge, and skill acquisition, and to enhance the educational experience of health professions trainees. The lab was created by a core group of faculty members with a similar passion for the application of technology to effectively educate learners. The team wanted to create an education-based research entity and to promote an environment of collaboration and mentorship within the department. The TIER lab is led by two PIs who also co-direct a medical education fellowship. The lab is part of the larger Texas Emergency Medicine Research Center (TEMRC), which is a translational research center focused on implementation science. 14 The TEMRC team includes clinician-scientists as well as three research nurses, six research coordinators, seven research assistants, and a biostatistician. By positioning itself under the umbrella of TEMRC, the lab can share resources that efficiently facilitate projects.

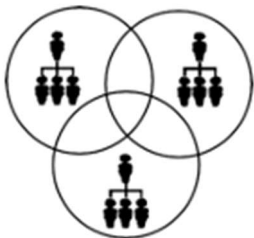
Centers 	Sometimes called “units”, “institutes” or “centers”, these groups are usually institution-wide research enterprises that support multiple senior scientists who may or may not share a common research agenda, but all work within the field. The establishment of a center is usually a very formal research endeavor that has specific organizational criteria. These are usually either donor-funded or centrally-funded. Some have the capacity to grant degrees or engage in their own internal hierarchy or promotion process.
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Gordon Center. The Gordon Center for Simulation and Innovation in Medical Education was established in the 1970’s as a University of Miami Center of Excellence to direct and foster health sciences education research initiatives. From its inception, a focus of this research has been on the development and evaluation of innovative technologies, including simulation, for learning and assessment. Over time, this focus has broadened to other areas of medical education research to include outcomes assessment, implementation science, and human factors. The Gordon Center is self-funded through a combination of institutional, state, federal and foundational grants and has four, full-time faculty (each serving as PI on projects) who dedicate a minimum of 50% of their total effort to research initiatives. Its director reports to the dean and chief academic officer of the medical school. The Gordon Center collaborates on active research across several basic science and clinical departments, centers, institutes, and other schools at the University of Miami. In addition, the Gordon Center carries out research with several other national and international medical universities, societies, and organizations.

MERIT. Established originally in the 1970s, the McMaster Education Research, Innovation & Theory (MERIT) research unit has had several names over the years including ‘Program for Education Design’ and ‘Program for Education Research & Design’. Originally established to support the medical school at McMaster University in its design of their problem-based learning curriculum, this research entity has evolved over time through various phases. It functioned more as a multi-PI lab in the past, with members collaborating to develop and test innovations such as the multiple mini interview. More recently, it has evolved to be akin to many other medical education research units that are increasingly popular in Canada. These units serve to pool resources and act as a centralized developmental entity that allows for apprenticeship into the increasingly professionalized fields of medical education research and health professions education.

ZIEL Simulation Research CoLab. The Zamierowski Institute for Experiential Learning (ZIEL) serves as the simulation center for both the University of Kansas Medical Center and the University of Kansas Health System. Within ZIEL, the “CoLab” is a functional unit meant to lead or support research and assessment on high-priority challenges and interventions in individual and team learning and performance. This function was inspired, prior to ZIEL’s opening, by institutional leadership and benefactors recognizing the need for social and behavioral science expertise to advance ZIEL’s mission. ZIEL CoLab staff currently include a research director, assistant director, and a data specialist, with grant funding supporting research assistants per project needs. A key role of the CoLab staff is to build collaborations that advance both science broadly, as well as the

care improvement locally. Simulation scholars pursue diverse topics, though where possible, projects advance one or more common themes: (1) novel healthcare task analysis, (2) performance assessment, (3) sensemaking about experiences and performance data, and (4) data-informed, tailored interventions for learning and performance improvement. Along with direct project support, CoLab staff mentor new scholars and provide project-based learning around scholarship and research.

Collaboratives 	In contrast to centers that are more formal, some research enterprises arise more organically between like-minded researchers. Collaboratives are multi-PI groups that form project-specific teams but may revise membership from project to project. This contrasts them from networks, which often sponsor specific projects consistently within the same member group.
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METRIQ Study Collaborative. The Measuring Education and Translational Resources: Impact & Quality (METRIQ) Study Collaborative is a partnership of investigators at multiple institutions who organized their lab in 2014. METRIQ has conducted numerous research studies that advanced our understanding of how educational and translational online resources can be developed, measured, and evaluated for quality. The Collaborative has no physical home, but rather consists of collaborators that span multiple continents and have completed dozens of projects together. Several investigators serve as the lab directors charged with originating new studies, and they are supported by a network of members who lead specific initiatives and author papers. Not all members of the group are on every published paper, but rather, authorship mirrors the subgroups of investigators that combine and recombine to complete various work. METRIQ has a comprehensive website that tells the story of the lab through an archive of their published papers ordered as their narrative of work.

Translational Simulation Collaborative. The Translational Simulation Collaborative (TSC) was developed in 2019 as a nexus point for researchers and practitioners working to improve healthcare through simulation. Organizationally, The TSC is a research collaborative within Bond University at the Gold Coast, Australia, with formal partnership agreements with four major Australian health services. The director holds a conjoint professorial appointment, and governance and operational support is provided by Bond University. The focus of the research center and its affiliates is translational simulation practice: exploring health services challenges, testing potential improvements, and embedding better healthcare practices through diverse simulation techniques. This research bridges disciplines such as health professions education, quality improvement, and healthcare simulation. TSC serves as an umbrella lab for multiple organizational partners with complex financial arrangements, intellectual property issues, and potential conflicts of interest. This lab model was challenging to design; however it was necessary in order to assemble a critical mass of investigators within this niche discipline. The TSC uses ethnography and action research methods primarily, in part due to the unique dual qualifications in medicine and anthropology of one of the lead researchers. The TSC undertakes research and consultancy work, with the latter providing fertile ground for further collaborations and funding for research and development work.

Scholarship activity includes supervision of PhD candidates, medical students, simulation fellows, and visiting scholars. There are plans for an annual seminar, and for a Translational Simulation course to be offered within the Bond Masters of Healthcare Innovation. There is a non-financial partnership with the Simulcast podcast to enhance impact and dissemination.

ALiEMERLI. Academic Life in Emergency Medicine (ALiEM) is a non-profit, health professions education organization focused on social media technologies and community building. The ALiEM Education Research Lab and Incubator (ERLI)²⁷ is a collaborative research network within ALiEM focused on a data-driven approach to advancing medical education and peer mentorship of education researchers. Established in 2020, the ERLI represents the successful maturation and growth of the research arm of ALiEM's Wellness Think Tank. A Chief Academic Officer directs the network of co-investigators who share interests in specific lines of research, with their current efforts focused on physician wellness. Recent work includes the characterization of burnout prevalence among emergency medicine residents in the US, as well as a national assessment of wellness innovations implemented by emergency medicine residency programs. Research outcomes are disseminated in traditional journals and published on the ALiEM website for open access to interested stakeholders. The ERLI also offers a consultation service from a panel of medical education research experts for outside investigators who are designing new studies. The lab is not affiliated with a university and therefore does not qualify for many traditional funding mechanisms; support for ERLI research has been largely philanthropic.

TEaCH hub. The Technology, Education, and Collaboration in Healthcare (TEaCH) hub is an international digital collaboration that acts as a homebase for multiple PIs interested in technology, education, and digital networks. Six investigators direct the collaborative digital lab space, many of whom had successful collaborations together prior to starting TEaCH hub. Housed in a Slack® workspace (Slack Technologies, San Francisco, CA, USA), there are channels that act as “collabs” (spaces between labs), “labs” (where groups of individuals bandy around a topic/cause/group of studies), and “paper” or “grant” channels where members of a lab or collab work together to complete a given project. There is a shared academic and professionalism code of conduct, and one of the core principles of the hub is to encourage transparency and sharing, rather than competition and closed-door conversations. TEaCH hub has grown astronomically since its inception in March 2020, boasting more than 130 members, 6 PIs, and multiple projects, collaborations, grants, and papers. TEaCH hub sponsors a variety of synchronous programming (e.g. debates, discussions, socializing) that occur on platforms such as Zoom® (Zoom Video Communications, San Jose, CA, USA) and Sophya® (Sage Learning Inc, Boston, MA, USA).

Networks



In contrast to less formal collaboratives, research networks tend to be more standard in structure and aim to increase the multi-center nature of certain types of studies. Networks are often seen more often within clinical research to fulfil multicenter research trials, and site leads recruit for one or multiple projects at once. Members are loosely affiliated with one another through participation in these trials and may communicate infrequently.

Emergency Medicine Education Research Alliance. The Emergency Medicine Education Research Alliance (EMERA) was established in 2014 by a group of Northwestern University emergency medicine residency graduates with an interest in medical education research, and it has expanded its membership of investigators yearly; there are 15 current investigators. Members have a breadth of formal research training and serve in various educational administrative roles including residency program director, medical student clerkship director, and medical simulation center director. Member sites are distributed in all major geographic regions of the United States. The mission of EMERA is to conduct multi-institutional research developing educational best practices in emergency medicine. The group has traditionally focused on graduate medical education but has recently begun studying emergency medicine physicians-in-practice. Areas of focus of past and present multi-institutional projects include emergency medicine resident wellness, burnout, grit, firearm safety, patient safety simulation, and various curricular needs assessments and interventions. Individual member participation and authorship is study specific. Structurally, the group meets virtually monthly and in-person at professional society meetings. The role of president rotates yearly and is self- or peer-nominated and then selected through group consensus.

CanDREAM Team. The Canadian Data Research for Evaluation and Analytics in Medicine (CanDREAM) Team was established in 2018, one year before the Royal College of Physicians and Surgeons in Canada implemented a nationwide, competency-based medical education assessment framework. Three education researchers started CanDREAM to study this implementation and quickly recruited a wide network of educators from nearly all physician training programs in Canada. Residency program directors or their designees initially served as site coordinators who gathered data for the first CanDREAM study, a program evaluation examining the fidelity of implementation in the first year of the nationwide curriculum. This group is currently planning further multi-center collaborations to discern curricular outcomes of this new pan-Canadian initiative. A core group of investigators (n=4) are leading this larger team to develop new tools (e.g. digital redaction tool), natural language processing/machine learning innovations, automated scoring tools, and validation of rubrics.