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An Open-Source Curriculum to Teach Practical Academic Research Skills

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PROBLEM: THE NEED FOR A PRACTICAL RESEARCH SKILLS COURSE

Academic productivity is critical for trainees' career advancement.[1] Research enhances knowledge and advances the development of specialty interests, and facilitates connections with mentors; peer-reviewed publications are common among those matching into many academic surgery residency programs.[2–4] Even after matching into residency programs, trainees commit to research time in the middle of clinical training to further develop nontechnical skillsets, and academic productivity remains important for securing fellowship and faculty positions.[5] While many institutions offer grant writing or biostatistics courses, teaching practical skills—such as writing concisely, designing effective figures, and responding to reviewers—are commonly relegated to individual mentors. Without intentional instruction from experienced mentors, acquiring these essential skills can be highly variable and challenging.

APPROACH: INTEGRATING A PRACTICAL RESEARCH SKILLS COURSE WITHIN STANFORD SCHOOL OF MEDICINE CURRICULUM

We designed a course to teach practical skills to propel trainees' academic readiness. Our aim was to provide medical students with foundational research knowledge to build upon throughout their training. The "Practical Introduction to Academic Research" course was designed and taught by a research resident (J.C.) with 2 faculty supervisors (L.M.K. and J.R.K.). Stanford's preclinical medical curriculum comprises scholarly concentrations, wherein students undergo in-depth training in one of several areas of study (eg, surgery, quality improvement, and global health).[6] In the spring of the first year, most students apply for an internal Medical Scholars Research grant, which supports summer research between first and second years, and beyond for those who pursue dedicated research time. Our elective course taught weekly in 10 sessions throughout the winter quarter, was integrated within the Surgery Scholarly Concentration. In contrast to existing courses that explore specific aspects of academic research (eg, grant writing and biostatistics), we aimed to systematically teach practical skills that could elevate students' productivity and research quality—skills often assumed to be taught by research mentors. We compiled a list of potential summer research projects from medical school faculty before the first class, and students applied lessons from each lecture to complete a written grant proposal and deliver a 3-minute oral presentation on their summer project plan. Instructors' feedback on the grant proposal facilitated students revising a refined draft with their research mentors in time for the Medical Scholars Research grant submission deadline.

OUTCOMES: A PRACTICAL INTRODUCTION TO ACADEMIC RESEARCH CURRICULUM

One-third of first-year Stanford medical students enrolled, with enrollment increasing from 19 to 30 over its first 2 years of offering. We made our syllabus and slides publicly available to facilitate course replication at peer institutions.[7] We highlight the key course contents below.

Productivity

Adopting productive habits can maximize time spent conducting research and translating into peer-reviewed articles. Amidst busy clinical rotations and other commitments, blocking off dedicated daily time for research (ie, even 15 minutes) and mitigating distractions is essential. Working in parallel (eg, one member completing the literature review and drafting the introduction, methods, mock tables, and figures, whereas another conducts data analysis) expedites project completion. Table 1 highlights other strategies to maximize productivity.

Study Design-Specific Suggestions

Every article should follow the study design-specific reporting guidelines [eg, observational studies—Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)]. The guideline checklist should be submitted as a supplement (checklists are available from the EQUATOR Network).[8]

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TABLE 1.

Research Foundations

Concept	Recommendations
Productivity	Produce a peer-reviewed publication for every project
	Block off dedicated time for daily research (eg, even 15 minutes)
	Adopt productive habits (avoid multi-tasking, block times for checking email, minimize switching tasks)
	Find mentors with a track record of successful peer-reviewed publications with trainee first authors
	Do not start projects you can not finish: gauge your and your mentor's time, interest, and skillsets
	Set strict internal timelines
	Work in parallel within teams
Data organization	Create a thorough data dictionary with standardized value options for each variable
	Use lowercase and underscore ("_" instead of spaces) for variables names and values (facilitates data analysis)
	Use "0" and "1" for binary variables
	Perform a test extraction among team members and regroup to resolve
	concerns before full data extraction
Citation stewardship	For every cited fact, cite material after reading article (i.e. not just the title/abstract) to ensure agreement with authors' findings
	Cite the primary source rather than the reference of a reference
	Assess whether extrapolating an article's population is appropriate
	Recognize that the number of citations is not a proxy for quality (a high citation tally may reflect the Matthew effect, wherein "the rich get richer")
PubMed booleans and operators	Use "AND" when the reference should contain each search term in the query
	Use "OR" when the reference can contain any of the search terms in the query
	Use "NOT" when the reference should contain none of the search terms
	Use parentheses when conceptual units are grouped together
	Use wildcards ("*") when there are variants in spelling or word endings
	Use phrase searching ("_") when an exact term is desired

Many trainees conduct institutional chart reviews or systematic reviews. Drafting skeleton figures/tables and building a standardized data extraction sheet comprising all variables to complete them mitigates repeat extractions. A data dictionary specifying entry options for each variable (eg, lower case, underscore rather than space, 0, or 1 for binary variables) expedites downstream analysis. Conducting sample extractions and regrouping to share strategies or pitfalls can optimize efficiency among multiple extractors (Table 1 data organization).

Reference Management

Inaccurate citations abound in the surgical literature.[9] To avoid promulgating misinterpreted or inaccurate facts being cited as "evidence", every citation must pass a thorough checklist (Table 1 citation stewardship). Reference managers such as Zotero, Endnote, or Paperpile facilitate accurate citation tracking through multiple article iterations.[10–12]

Searching the Literature

Using field tags (eg, title [ti] and textword [tw]), medical subject headings [MeSH], booleans, and operators facilitate retrieving comprehensive and relevant PubMed citations. (Table 1 PubMed search strategies).[13]

Statistical Analysis

Sound study design and statistical analysis are essential for every project. Clinical literature abounds with common statistical mistakes; recognizing and avoiding these mistakes is important (Supplemental Table 1, http://links.lww.com/AOSO/A247 statistical pitfalls). For example, *P* values are often misinterpreted:[14] small *P* values alone do not imply meaningful statistical significance (appropriate study design, data source, and hypothesis test are essential) or large effect sizes. The prevalent threshold of "<0.05" is arbitrary. Statements regarding both statistical and clinical significance require thoughtful consideration of study design and data limitations, including unmeasured confounding and biases. Consulting a statistician is essential for every article.

Manuscript Writing

Following a systematic template for every article facilitates succinct writing.[15] Aforementioned study design-specific guidelines delineate the required content for each article section.

The *introduction* should achieve 3 objectives: (1) highlight why readers should care about the study; (2) demonstrate a knowledge gap in existing literature (and why this gap is important to address); and (3) state the study's aim and hypothesis. Using the phrases, "we aimed to" and "we hypothesized" accomplish the third objective explicitly.

Subheadings (eg, "study population", "primary outcome", and "sensitivity analysis") should delineate relevant subsections in the *methods* and *results*. Methods should be clear enough to facilitate study replication; allocating details to the supplement can keep the main text succinct. Sharing analytic code and deidentified data (if regulations allow) promotes transparent science. *Results* should state objective findings without commentary. Tables and figures facilitate keeping the text concise. Informative tables and figures should deliver the article's key findings on their own (Supplemental Table 1, http://links.lww.com/AOSO/A247 informative tables and figures).

The *discussion* should summarize key findings, place findings in the context of existing literature, suggest implications for current practice, recognize limitations, and suggest future research or practice directions. Over-interpreted findings prompt article rejection decisions. Every study has limitations, yet acknowledging limitations alone is insufficient. A logical argument should outline efforts to address limitations (eg, sensitivity analysis to address unmeasured confounding) and convince why findings and their implications remain relevant.

Refining the article through multiple iterations facilitates eliminating nonessential content (Supplemental Table 1, http://links.lww.com/AOSO/A247 iterative writing). Reviewing commonly misused words can be helpful (Supplemental Table 1, http://links.lww.com/AOSO/A247 word choice).

Visual Abstracts

Visual abstracts convey essential findings in one slide, are associated with an increased number of citations, and are mandated by a growing number of journals.[16]

Targeting Appropriate Journals and Drafting Cover Letters

A succinct cover letter outlining study findings and their importance should convince editors that the article's quality and content are appropriate for the journal audience. Beyond seeking an experienced mentor's advice, reading recent articles from target journals and reviewing where referenced articles were published may guide journal selection.

Responding to Revision Requests

Peer reviewers volunteer considerable time to provide helpful suggestions. Every suggestion warrants a gracious and thoughtful response. A well-formatted response letter (eg, numbered reviewer suggestions, followed by bolded author response, and revised article text in *italics* [*added text highlighted and removed text crossed*]) facilitates re-review.

Delivering Great Presentations

Delivering one key message without losing the audience's attention is essential. Outlining the study aim and why the audience should care may be sufficient for the *background* (ie, US trauma surgeons would not need another reminder that injury is the leading cause of mortality among young American adults). Detailed methods are challenging to follow and may lose many audience members' interest. Beyond a high-level overview to portray appropriate study population selection, study design, and analysis, a QR code can direct interested audience members to detailed methods written in a Google Drive document. If results comprise tables, all cell values should be visible for the farthest-sitting audience member (in general, >28 pt font). Multiple practice runs should ensure presentation delivery within the allotted time.

Slides should comprise minimal words and be simple (eg, black font, white background). Slide real estate should maximize content delivery. For example, rather than displaying the section (eg, "introduction", "methods"), the top banner should state the slide's takeaway. Supplemental Figure 1, http://links.lww.com/AOSO/A247 highlights suggestions on building effective presentation slides.

NEXT STEPS

"A Practical Introduction to Academic Research" course teaches practical skills to propel trainees' academic productivity. From teaching how to adopt productive habits to responding to revision requests and designing effective presentation slides, the course fills an educational gap that existing institutional courses do not address. Our course targeted medical students and facilitated early connections with surgical faculty mentors, which may be beneficial for specialty recruitment but could be helpful for trainees at any stage. We believe this content summary and our open-source course material can help educators at many peer institutions propel their trainees' successful academic careers. We did not follow up with students after the course as some projects may take years to complete, but the next steps may include ensuring the practical skills taught translated to publications, thereby demonstrating the efficacy of the course and benefit to faculty as well. Longer-term goals may also include following up with students during residency and practice to assess how this course contributed to academic productivity and future careers in academic medicine.

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