Introduction

In the last several decades, medical student education has changed dramatically from the idealized and antiquated images commonly presented in literature and the popular media (Figure 1). Progressively, medical school curricula have seen the introduction of problem-based learning, community outreach, cultural awareness, ethics in medicine, and other humanist elements. These have replaced the traditional curriculum and primarily at the expense of didactic lectures.

A more recent inclusion, notable in trending back towards scientific medicine, has been broad-scale introduction in most US medical schools of a research experience for medical students. The nature and size of these research experiences vary widely from school to school, but the common theme is a block of time wherein medical students are released from some (rarely all) medical subjects to perform research under an established scientific or clinical mentor.

In choosing to remove valuable time from academic medicine, medical education specialists (including professors responsible for curriculum development as well as medical school administrators and Deans) must ensure that the benefits of a research experience outweigh the consequences of compressing an already tight learning schedule. If the programs providing research experiences are managed optimally, involving input from administration, scientific/clinical mentors, and the students; a research experience can benefit the student greatly, strengthen faculty/student and clinician/scientist relationships, and enhance the reputations of those involved, including institutional reputations.

At the John A. Burns School of Medicine (JABSOM), research for medical students has evolved since 2006 to include; a dedicated block of curricular time for a research rotation, centralized coordination through the Office of Medical Education (OME), courses offered for credit that appear on student transcripts, and an annual biomedical sciences symposium (coordinated by the Department of Cellular and Molecular Biology) for research dissemination. The following is a description of the impact of this evolution on medical student education, including the author’s experiences and recommendations for mentors offering clinical, translational, and basic science research projects for medical students. The discussions include concluding remarks on how research experiences assist medical students in their future careers.

Finding Space in the Curriculum and Fitting in Time for Research

Formalized research experiences come at the expense of traditional didactic lectures, which places pressure on the curriculum (and on the individual student), and often results in minimizing time spent on research. For a meaningful experience, a basic requirement is an unbroken block of at least 4-6 hours per day, for one or two days per week over a six-week period. At JABSOM this has been achieved by offering research rotations during the summer months in one or both of two, six-week blocks. Moreover, at mentors, and students, joint request, the OME may approve a for-credit experience in fall or spring units.

These research experiences usually begin with 8-12 hours of training to bring students to proficiency with basic laboratory equipment such as tissue handling devices, pipettors, pH meters, plate readers, and microscopes. More technically demanding techniques or equipment (notably analytical methodology) can require two or three training sessions. It is important that students are provided appropriate time at the beginning of their internship for training and learning. A poorly trained student will be unhappy, will not produce good scientific results, and may even break or disable essential laboratory equipment. Negative outcomes caused by insufficient or inadequate training are the responsibility of the mentors.

Once training is completed, sufficient time must be set aside for actual research efforts. A common example for medical student projects are those based on clinical chart review and statistical analyses of results. It is unusual for a person undertaking their first chart review to appreciate the amount of time and effort required to comb through even a single clinical record. The mentor must be cognizant of the time required, the availability of the student, and plan as well as advise the student accordingly. It is important that students honestly commit their time and effort if they wish to see excellent outcomes. The following is the first of several examples where communication is of utmost importance. The expectations of the researcher, including their knowledgeable assessment of time requirements, must be communicated to the medical student. Similarly, the medical student needs to be honest and forthright on their availability and commitment.

A way in which medical student research projects can be accelerated is by having technicians, graduate students, post doctoral fellows or residents collect clinical samples, prepare
tissues, and ribonucleic acid, and make buffers so that the medical student intern is performing the “important” scientific experiments. This is useful for maximizing the research experience, but short-changes the medical student on a true understanding of the time and effort required to prepare top quality clinical, translational, or scientific work. Clinical Fellows performing research have remarked to the author that they had “no idea” of the staggering level of work and time that go into collecting tissue, preparing samples, preparing buffers, and so on, let alone optimizing and performing the actual experiments prior to analyzing data. Likewise, there is a logical temptation for many mentors to have staff or statistical collaborators perform data analysis so that the student “just has to graph” the results. Again, this is valuable in giving the medical student a taste of research by training them to perform key experiments and also accelerates data acquisition for the mentor, but it also excuses the student from the rigors of data analysis. Either or both of these approaches are logical, defensible, and useful, although they ultimately confer a less rich and less complete experience for the medical students.

While it may not be feasible for the medical student to collect all of their own tissues or analyze all of their own data, valuable experiences can be had from participating it at least one collection or performing the analysis of a subset of the results. In this manner each student has an appreciation of the time, commitment, and care needed in both the set-up (front end) and concluding (back end) stages of research; yet, attains an accelerated experience. If the goal of medical student research experiences is to understand how medicine, science, and society come together, then a full appreciation of research preparation, set-up, performance, analysis, and communication are important.

Centralized Co-ordination and Identifying Appropriate Mentors
With the formalization of research experiences at JABSOM, it has been useful and successful to centrally coordinate research activities in the Office of Medical Education. The office coordinates medical student research experiences/rotations annually to allow medical educators to identify mentors that students would not otherwise approach.

Matching Students with Researchers
Annually, a list of researchers, their specialties/interests and capacity for offering internships is collected, collated, and presented to students to select from, on a first-come-first serve basis. More than just medical education, this practice has also strengthened student-faculty relationships. For example, JABSOM, like most US medical schools, has a separate building for research and medical education. In the “research” building, the majority of professors have no teaching commitments or interaction with medical students. Additionally, and also similar to many US medical schools, the hospitals where clinical learning occurs are remote from our teaching campus. Many physicians in Hawai‘i perform excellent research and, while a significant proportion of these physicians have appointments at the Medical School, many do not interact with medical students until the 3rd or 4th year. The centralized process described for mentor identification whereby a list of research mentors and their available projects is provided, enables students to identify the best researcher whose interests most closely align with their own, despite a lack of familiarity between individuals.

Optimizing Project Design for Medical Student Learning and Scientific Outcome
Having identified clinicians and scientists willing to mentor medical student research, consideration must be given by individual mentors to the most appropriate and high yield projects for these students. Medical students present an extremely attractive pool of talent for research since they are intelligent, motivated, and can rapidly acquire concepts and techniques. However, they do not have the time commitment nor future career outlook of a graduate basic science student. Hence research projects for medical students need to be designed accordingly. Primarily, a project with clear clinical or translational relevance should be presented. Unlike basic science students who may be academically stimulated by the question-and-answer paradigms or problem-solving aspects of research, most medical students seek a clinically relevant focus with immediate or potential outcomes.

Insofar as outcomes and research should be human focused, it is recommended and desirable to have human subject research approvals or animal use protocols in place before the student begins. Medical students should not be expected to write time-consuming protocols for approvals. In addition, retroactive approval for work performed is seldom, if ever, ethically acceptable.

Incoming students should be given a short summary of their project encompassing a summary of the background including hypothesis, brief overview of methodology to be used, predicted results, and projected project outcomes. Project outcomes span a spectrum of deliverables from knowledge acquisition, through oral or poster presentations to a possible publishable paper. If a mentor has insufficient time to prepare this document (generally two pages) in the months preceding a student’s arrival, and which can commonly be gleaned from existing resources, mentors should strongly consider whether they have appropriate time for students.

Project design is also important. Where possible, projects should have a solid, single ended non-conditional hypothesis that will result in a “yes” or “no” answer. This requires that the project have an inevitable conclusion. Open-ended projects that are generally non-hypothesis driven, based on conditional hypotheses or on “what if” type of questions, will not have a concrete conclusion. The consequences of this are a feeling of incompleteness when the student concludes their research rotation. In such instances, individual students may feel obliged or be coerced to keep working for their mentors with no end in sight, potentially to the detriment of the student’s medical education.
Another important issue in research is ownership. While it is indisputable that the mentor is the primary designer, compiler, curator, financier, and owner of data produced, students should be given credit for their work. Insofar as research can be analogized as a team effort, the medical student is a valuable member of the mentor’s research team and while all the team members contribute, each individual needs to be recognized.

Ideally, all students can and will contribute to research that is meaningful, to be communicated as a case report, clinical observation, or research paper. However, more appropriate outcomes of the “smaller and safer” projects described herein, may commonly be posters or Power Point (oral) presentations at local, national, or international meetings. For this purpose the growth of the annual two-day Biomedical Sciences Symposium held at JABSOM has been invaluable. This symposium is poster-based, contains categories for undergraduates, graduate students, medical students, and fellows/faculty. Prizes are awarded for best poster presentation in each category. This is an important venue for building verbal communication and presentation skills in medical students (and others). It is also valuable for building faculty-student relationships and faculty-faculty relationships. The entire school comes together to discuss medicine and research.

Benefits to Future Medical Careers

Participating in a research experience has more far-reaching consequences than the immediate outcome of paper publication or research presentations. Having formal university credits for research on a transcript and for some, a letter of support from the research mentor, enhances the competitiveness of medical students for residencies. This activity, contributes to students’ happiness and satisfaction in achieving their goal in medicine. It also enhances the prestige of the medical school and community when its students successfully gain competitive Residencies.

Additional intangible effects may occur in students’ future careers. All students are required to keep detailed and accurate laboratory notebooks documenting their work. For many, this is the first time they have been required to provide a clear and accurate account of a discrete experience. It is common to remind medical students to record their work completely, accurately, and in great detail. Clearly, the acquisition of these skills early in a medical career has obvious advantages for improved charting and clinical note taking.

Another benefit is improved understanding, diagnostic techniques that may be gained from a research experience. Physicians regularly order laboratory-based tests and while an encyclopedic understanding of these is unnecessary, a deeper appreciation of the methods used and problems experienced may ensure judicious use of diagnostics, sample collection, and outcomes.

Figure 1. Anatomy Lecture Room. Drawing by Henry Hollingsworth Smith (1854).
Finally, a research experience during medical school years is invaluable for those physicians who choose to become researchers, who partner with a scientific researcher for investigations, or who encounter researchers in their practice. The understanding of appropriate experimental design, procedures, and analysis, including the time commitments conferred by their research experience can enhance their future efforts immeasurably and increase the success of others with whom they collaborate or interact.

Concluding Remarks

The JABSOM approach to providing a research experience for medical students has evolved into a well coordinated and beneficial exercise, with significant positive impacts for students, faculty, and the school. Mentors need to keep in mind the commitment they make to each medical student intern, including appropriate project design, training and availability of human and experimental resources, and laboratory space when agreeing to offer a research experience. The benefits of a research experience reported by many current and former students argue strongly for the validity and contribution of research to medical students’ education and to their future as physicians.

References