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Does Undergraduate Student Research Constitute Scholarship? Drawing on the Experiences of One Medical Faculty

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Abstract: While undergraduate research has been part of the learning culture in some disciplines for many years, it is only more recently that it is being included into mainstream medical curricula. Undergraduate medical students at the Faculty of Medicine and Health Sciences, United Arab Emirates University, have several opportunities to undertake research during their studies, both locally and abroad. Following a documentary analysis of curricular and extra-curricular research over the past five years, supervised undergraduate student research activities and outcomes were compared with published criteria for scholarship and were judged to meet the standards. Suggestions for improved productivity relating to student research have been made.

Keywords: medical student, productivity, scholarship, undergraduate student research

I. Introduction.

Although student research has been integrated into many undergraduate programmes across a number of disciplines (e.g. Pyschology, Kierniesky, 2005), it is only recently that research experience is being included in the mainstream medical curriculum (Rhyne, 2000; Zier and Stagnaro-Green, 2001; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Marušić and Marušić, 2003; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005; Joubert, 2006). This trend should, however, not be surprising, considering that evidence-based practice requires clinical decisions to be founded on a sound understanding and use of scientific and biomedical research principles (Sackett, Rosenberg, Gray, Hayes and Richardson, 1996). Apart from the benefit to patients of physicians who use appropriate evidence to inform their clinical decisions (of whom Abraham Flexner would be proud), research experience influences residency selection and career choice (e.g. academic medicine and post-graduate research) (Segal, Lloyd, Houts, Stillman, Jungas and Greer, 1990; Brancati, Mead, Levine, Martin, Margolis, and Klag, 1992; Rhyne, 2000; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Chongsiriwatana, Phelan, Skipper, Rhyne, and Rayburn, 2005; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005). In a profession plagued by declining numbers of academic physicians and "endangered" disciplines (Association of American Medical Colleges, 2001; Zier and Stagnaro-Green, 2001; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Friedrich, 2003; Schor, Troen, Kanter and Levin, 2005; Wagner and Ioffe, 2005; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005; Gallin and LeBlancq, 2005), the inclusion of research into medical curricula is indeed good news.

A review of the literature reveals that research opportunities for medical students range, on the one hand, from negligible, especially in developing countries (Aslam, Shakir and

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Qayyum, 2005), to the inclusion of special study modules (Murdoch-Eaton, Ellershaw, Garden, Newble, Perry, Robinson, Smith, Stark and Whittle, 2004; Schor, Troen, Kanter and Levin, 2005) or electives (Remes, Helenius and Siniaari, 2000; Marušić and Marušić,, 2003; Houlden, Raja, Collier, Clark and Waugh, 2004) or perhaps extra-curricular research (Solomon, Tom, Pichert, Wasserman and Powers, 2002; Reinders, Kropmans and Cohen-Schotanus, 2005). At the other extreme, a research dissertation or project may be required, as is the case for many German medical faculties (Altunbas and Cursiefen, 1998; Cursiefen and Altunbas, 1998; Dewey, 2003) and some North American medical colleges (Jacobs and Cross, 1995; Rhyne, 2000; Chongsiriwatana, Phelan, Skipper, Rhyne, and Rayburn, 2005). These institutions have generally adopted a "scientific model" of learning, which is centred on the discovery (rather than the transmission) of new knowledge (Gonzalez, 2001).

Faculty members who supervise and mentor student undertaking research potentially benefit as they can increase their scientific productivity (Wagner and Wagner, 1992; Jacobs and Cross, 1995; Curseifen and Altunbas, 1998; Morrison-Beedy, Aronowitz, Dyne and Mkandawire, 2001; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Cardosa, Silva, Netto, Touca, Pacheco, Mattos, Brigido and Cavalini, 2005). At one German school, where students appeared as authors on 28% (7.8% as first author) of the institution's publications (Curseifen and Altunbas, 1998), two-thirds of faculty members acknowledged that student research contributed qualitatively and quantitatively to the high productivity of the faculty (Altunbas and Cursiefen, 1998). Considering that research plays a major role in academic appointments, tenure and promotion, not only in many medical faculties but in tertiary education in general (Boyer Commission, 1998; Adderly-Kelly, 2003), student research, if appropriately supervised, has the potential to contribute significantly to the research profile and scholarly achievements of individual Faculty members as well as the productivity and reputation of the academy.

The present contribution will describe undergraduate student research (curricular and extra-curricular) at one medical school (Faculty of Medicine and Health Sciences, United Arab Emirates University), and then compare the activities and outcomes of this research with the published standards of scholarship (Table 1). We will argue that undergraduate student research constitutes scholarship, in this case, the *scholarship of discovery*. Research scholarship is one of four scholarships identified by Boyer (1990) in his landmark publication, *Scholarship Reconsidered: Priorities of the Professoriate*, in which he attempted to bridge the age-old divide between research and teaching in Higher Education.

II. Student research at the Faculty of Medicine and Health Sciences (FMHS), United Arab Emirates University (UAEU).

The broad mission of the FMHS undergraduate medical programme is to produce Emirati doctors educated to the highest international standards and who are sensitive to UAE health care issues. The six-year curriculum comprises two years each of a Medical Sciences Course, an Organ Systems Course (largely problem-based learning) and a Clinical Sciences Course (junior and senior clerkships). Females account for around 75% of the annual intake, which has ranged from 29-60 students. Faculty members are appointed on contract, largely on their research and teaching excellence.

Table 1. Application of Glassick and colleagues' (1997) and Glassick's (2000) criteria for evaluating Boyer's (1990) scholarship of discovery (research) to student research activities and outcomes at the Faculty of Medicine and Health Sciences, United Arab Emirates.

Criterion	Application to Discovery	Examples of student activities meeting each criterion
Clear goals?	• Clear hypothesis? • Appropriate research questions? • Realistic and achievable objectives?	• Required for ethics application • Required for ethics application • Presented and evaluated by Ethics Committee. Students questioned about feasibility considering that the research is part-time and relatively short-term (4-5 months)
Adequate preparation?	• Understanding of existing scholarship in the field? • Necessary skills? • Appropriate resources?	• Literature review/background required for ethics application and for final report • Will be learnt during the project, under supervision • Supervisor's grant and laboratory. Students need to defend, e.g. sample size; use of animals *vs*. tissue/cell culture to the Ethics Committee
Appropriate methods?	• Methods appropriate for goals? • Effective application of methods? • Modify procedures in response to changing circumstances?	• Planned under supervision • Monitored. Most use statistics for data analysis • The progress report serves as a measure of the *status quo* of the research – involves self-evaluation and reflection. May involve adapting the methodology
Significant results?	• Goals achieved? • Did the work add to the field? • Does the work open additional areas for exploration?	• Projects are supervised and so the goals should be achievable if the research is well planned • Some student research has been published. Reviewers would have evaluated the research in terms of this criterion • Would depend on the type of research project. Project may be in the early stages of supervisor's research but it may also be in the final stages. Most research generates new questions
Effective presentation?	• Use suitable style and effective organisation to present work? • Appropriate fora? • Presented with clarity and integrity?	• Poster or oral presentation at various conferences. Students usually decide: Junior students prefer posters. Some have won prizes for their presentations, attesting to "effective presentation" • GCC Medical Student Conferences; UAEU Research Conference to showcase Faculty and student research. Supervisors may present at discipline conferences locally and abroad • Prizes attest to quality and excellence. Acceptance of peer-reviewed articles is also evidence
Reflective critique?	• Critically evaluate own work? • Appropriate breadth of evidence to critique? • Use evaluation to improve future research? **University of Ottawa (2001)*** **Level 1**. Supportive of students and trainees pursuing research	These questions are addressed in a progress report, mid-way in the allocated research time. Evaluation and reflection on progress may require modifications to methodology, data analysis, omissions, etc. In preparing final results for public scrutiny (i.e. poster at conference, article for publication), students and supervisors acknowledge limitations, suggest possible future research as well as decide whether the work is of a sufficient standard to be scrutinized publicly. Supervision of second year students and other students volunteering for summer research

* Criterion extracted from the University of Ottawa's (2001) review form for Faculty scholarship.

In line with global trends in medical education reform and the requirement to practice evidence-based medicine in a rapidly advancing technology-driven, information-loaded world, research projects were included in the FMHS undergraduate medical curriculum. Community Medicine projects were part of the curriculum for the first cohort of sixth year clerks (1992), while second year projects were introduced in 2001. Since 2003, extra-curricular research has also been possible locally and abroad during the summer for all FMHS students at all levels of study.

A. Mainstream curriculum research: Second year research projects.

In the first semester of their second academic year, students choose research projects. These projects can be laboratory- or community-based, clinical or a combination, or perhaps in

medical education, depending on which Faculty members offer topics. Students can also propose their own research ideas and provided the project is feasible and a Faculty supervisor is available, their requests are accommodated. A Study Guide outlines the objectives of the research project in terms of teamwork, ethical considerations, data management and written and oral communication skills, while a series of lectures, seminars and workshops introduces students to the requirements of scientific and biomedical research (e.g. ethical application, data collection and analysis, statistics, presentation of results). Following a presentation to the Ethics Committee and the granting of approval, groups of 2-5 students spend 4-5 months in dedicated sessions conducting their research under the supervision of a Faculty member. A summative group mark (i.e. required to pass to progress) is awarded, derived from a presentation to the Ethics Committee, a progress report, a poster presentation and a final written report in the style of the *Emirates Medical Journal (EMJ)*. Abstracts from student research are published annually in the *EMJ*. Students are also invited to submit abstracts for the annual UAEU Research Conference and the Gulf Co-operation Council (GCC) Medical Students' Conference, an event that rotates around the Gulf region each year.

B. Mainstream research: Sixth year Community Medicine projects.

Since 1992, a community-based project has formed part of the final year Community Medicine clerkship. The objectives are similar to those of the second year projects (i.e. team work; ethics; communication skills; research methodology). Research generally involves students interacting with UAE communities to investigate health and safety issues impacting on their well-being. The same opportunities afforded to second year Medical Science students (e.g. UAEU Research Conference, and more recently, the GCC Medical Students' conferences) are available to these senior clerks.

C. Extra-curricular research at the FMHS and abroad.

Since 2003, up to one quarter of FMHS students from all levels of study, but recently increasing numbers of junior and male students, have volunteered for extra-curricular summer research (Table 2). In the 2006 academic year, almost 60% of the first year and ± 44% of Year 2 students

Table 2. Summary of students (gender, year of study) who participated in extra-curricular research at the FMHS during the summers of 2003-2006.

		% males and females (Years 1-6)		% of year cohort per academic year					
Academic year (*n* = number of students)	**% of cohort participating**	**% Males**	**% Females**	**1**	**2**	**3**	**4**	**5**	**6**
2003 (*n* = 224)	25.4	13.1	30.1	34.5	11.8	49.2	17.5	18.2	2.6
2004 (*n* = 219)	17.4	7.8	21.3	20.0	31.0	33.3	12.5	7.5	0
2005 (*n* = 234)	22.2	21.2	23.8	46.7	22.9	63.0	9.1	5.4	0
2006 (*n* = 242)	22.7	31.9	19.1	58.5	43.6	6.5	18.5	0	0
Average (*n* = 230)	**21.9**	**18.5**	**23.6**	**39.9**	**27.3**	**38.0**	**14.4**	**7.8**	**0.7**

participated. In addition, each year, two or three students, selected for their academic and research excellence, are sponsored through a joint initiative of the British Council and the FMHS to undertake research at a number of United Kingdom universities (Table 3). Historically, Year 4 students have travelled abroad, but in 2006, the students were in their second or third year of study. The first male student was selected in 2006. He presented his research at three conferences (one international, at which he won an award).

Table 3. Details of students sponsored to undertake extra-curricular summer research abroad (2003-2006).

Year	Students	Year of study	Discipline	Conference presentations
2003	2 females	4	Physiology; Anatomy	
2004	2 females	4	Physiology	2005 UAEU Research Conference
2005	2 females	4	Physiology	
2006	2 females 1 male	2; 3 3	Microbiology; Anatomy Physiology	2006 Physiological Society (UK) Meeting + poster at visiting university's Research Day + *YES conference (prize awarded)

*YES – Young European Scientists

III. Does undergraduate student research at the FMHS constitute scholarship? How do we measure this scholarship?

While there is anecdotal evidence suggesting that student undergraduate research contributes to scholarship in the Faculty (e.g. winning prizes at conferences, authors on journal articles), student research has not been formally evaluated or audited. As it had been approximately 5 years since the introduction of second year projects, and since the extra-curricular summer research was becoming increasingly subscribed, an internal audit was initiated in terms of supervision, types of projects and student year of study.

For the present contribution, the primary query we set about answering was whether our undergraduate student research met the criteria for scholarship. We reflected on both the *process* and the *products* of the research. Included in the *process* are the activities in which students engage during the development, planning and execution of their research, while measurable *outcomes* (products) include conferences attended, awards won and publications appearing in peer-reviewed journals. We then applied published standards or criteria for measuring scholarship (Glassick, Huber, and Maeroff, 1997; Glassick, 2000). These criteria take cognisance of, amongst other things, planning, execution, hypothesis generation, interpretation, presentation and reflection (Glassick, 2000; Table 1).

A. What evidence supports the assumption that undergraduate student research constitutes scholarship?

A systematic documentary analysis of various Faculty and University publications and reports (e.g. Research Office, research project co-ordinator's list; *EMJ*; GCC Medical Students' Conference proceedings) provided much of the information and evidence to support our

assumption. This was supplemented by informal interviews with various Faculty members and email communication to validate and update provisional data and summaries.

Does student research constitute scholarship? If the published criteria for evaluating scholarship (Glassick, Huber, and Maeroff, 1997*;* Glassick, 2000) are applied to the many activities in which our students engage during their research, from preparation to final presentation, their involvement in both mainstream and extra-curricular research meets the recognised standards (Table 1). As *"scholars in training"*, under the watchful mentorship of their supervisors, students are guided through the rigours of scientific and biomedical research. Much of this introduction to critical inquiry takes place at the outset of their second year research project, when they prepare a proposal for the Faculty's Ethics Committee. Irrespective that they are research novices, they complete the same animal or human ethics application form as do Faculty researchers. This requires a literature review, development of a hypothesis, statement of research questions and methodological details including data collection and analysis, all of which are considered as criteria for measuring scholarship (Table 1). In addition, students undertaking animal research need to defend their use of animals (as opposed to cell or tissue culture) and their chosen sample size. As a new staff member, I attended some of the students' presentations to the Ethics Committee. They were rigorously interrogated about their methodology, resource use as well as time allocation. Such an experience, although intimidating for young students, is a valuable introduction to the rigours of scientific, biomedical and clinical research. Approval of a project proposal by the Ethics Committee would therefore attest to meeting the criteria of *clear goals, appropriate methods* and *adequate preparation* (Table 1).

Such an exercise would certainly contribute to their oral and written communication skills. It would also develop their organisational and critical thinking skills (Remes, Helenius and Siniaari, 2000; Frishman, 2001; Joubert, 2006). Such generic or transferable skills are required to prepare students for life-long learning (Whittle and Murdoch-Eaton, 2001; 2002; Murdoch-Eaton, Ellershaw, Garden, Newble, Perry, Robinson, Smith, Stark and Whittle, 2004).

As students progress through the 4-5 months of their research, they continue to develop existing skills and acquire new ones as they learn to conduct experiments or interview patients or members of the community, use statistics to anaylse data, write a progress report, and finally, prepare research results for peer-review and public scrutiny. Writing a progress report mid-way through the research project, in which revisions may be required (e.g. improving the research methodology, making decisions about how best to present the results or identifying limitations of the research in the final report), all require reflection and introspection. These activities meet the standard of *reflective critique* (Glassick, Huber and Maeroff, 1997; Glassick, 2000).

Making public one's research results at appropriate fora, as many of our students (or their supervisors) have done regionally and internationally can be viewed as *effective presentation* (Glassick, Huber, and Maeroff, 1997; Hutchings and Shulman, 1999; Glassick; 2000). Our students have excelled in this regard. Table 4, which depicts FMHS students' poster and oral contributions to the GCC Medical Students' conferences, is evidence of their contribution to student research and scholarship in the Gulf region. Although the overall FMHS contribution is similar to that of Saudi Arabian students, cognisance should be taken of the smaller FMHS cohorts ($\pm$ 45 *vs.* > 100). Saudi Arabia is also represented by at least four medical schools.

Several FMHS students and some of their supervisors (on their behalf) have also presented at international conferences (Table 5). More importantly, and more scholarly, are the number of prizes garnered at these and other conferences (Table 5). In our opinion, being awarded prizes attests to the quality and the *effective presentation* of their *significant results*.

Table 4. Comparison of FMHS students' contributions with other Gulf states to the GCC Medical Students' Conferences (2003-2006).

	% conference presentations				AVERAGE % (2003-2006)
Contributions	2003 (Bahrain)	2004 (UAE)	2005 (Kuwait)	2006 (Oman)	
TOTAL UAEU	***22.5***	***26.7***	***26.8***	***22.4***	***24.7***
TOTAL BAHRAIN	**20.8**	**8.5**	**14.6**	**9.3**	**12.5**
TOTAL KUWAIT	**3.8**	**14.9**	**34.2**	**5.6**	**8.9**
TOTAL OMAN	**18.9**	**12.9**	**18.3**	**35.6**	**22.0**
TOTAL SAUDI ARABIA*	**34.0**	**37.4**	**6.2**	**27.1**	**25.8**
TOTAL (*n*)	**53**	**94**	**82**	**107**	**336 (100%)**
All UAEU oral presentations	***16.1***	***27.3***	***32.2***	***16.3***	***22.5***
Oman	**19.4**	**21.2**	**16.1**	**30.2**	**22.5**
Kuwait	**6.5**	**18.2**	**25.8**	**7.0**	**13.8**
Saudi Arabia*	**35.4**	**21.2**	**9.7**	**30.2**	**24.6**
Bahrain	**22.6**	**12.1**	**16.2**	**16.3**	**16.6**
TOTAL Orals (*n*)	**31**	**33**	**31**	**43**	**138 (100%)**
All UAEU poster presentations	***31.8***	***26.3***	***23.5***	***10.9***	***26.3***
Oman	**18.2**	**8.2**	**19.6**	**37.5**	**21.7**
Kuwait	**0**	**13.1**	**39.2**	**4.7**	**15.6**
Saudi Arabia	**31.8**	**45.9**	**3.9**	**25.0**	**26.8**
Bahrain	**18.2**	**6.6**	**13.7**	**6.3**	**9.6**
TOTAL Posters (*n*)	**22**	**61**	**51**	**64**	**198 (100%)**

***Contributions from at least four medical schools**

The most definitive measure of the scholarship of discovery is, however, the acceptance of research findings for publication in peer-reviewed journals (Hutchings and Shulman, 1999). Reviewers, who are selected for their scholarship, critically evaluate the research against published standards of scholarship (e.g. *appropriate methods*; *significant results*) before accepting a submission on behalf of the journal. *Is the work reproducible? Is the research innovative? Does the research open new avenues of inquiry? Is it presented with clarity and integrity?* (Glassick, Huber and Maeroff, 1997; Hutchings and Shulman, 1999; Glassick, 2000). *Reflective critique* is also an important criterion that reviewers consider. *Have the researchers acknowledged the limitations of their study? Have they reflected on the impact of their research?* Some of our students appear as first or co-authors on a number of journal articles (Table 5), the research having emanated largely from interdepartmental collaboration. The productivity of student research has previously been reported as a measure of its success (and by implication, scholarship) (Wagner and Wagner, 1992; Altunbas and Cursiefen, 1998; Remes, Helenius and Siniaari, 2000; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Marušić and Marušić, 2003; Schor, Troen, Kanter and Levin, 2005).

Table 5. Conference presentations, prizes won and publications emanating from second and sixth year projects and from extra-curricular research for the period 2002-2006. The first GCC Medical Students' Conference was held in January 2003, where work from 2001 and 2002 was presented.

Year project undertaken	GCC Conference			UAEU conference	Prizes won	Other conferences	Publications emanating (including discipline of staff)
Year	**Oral**	**Poster**	**Total**				
2001/2				**2**		**3**	
Second year	GCC conferences not yet organised			0		0	
Sixth year				1		0	
Extra-curricular				1		3	1 Biochem/Pharm
2002/3	**5**	**7**	**12**	**4**		**4**	
Second year	0	2	2	0		0	
Sixth year	1	2	3	1		1	
Extra-curricular	4	3	7	3		3	1 Anat/Int Med/Pharm 1 Anat/Pharm 2 Internal Medicine 1 Surgery/Comm Medicine
2003/4	**9**	**16**	**25**	**1**		**4**	
Second year	4	4	8	0	Best poster GCC	0	1 Phys/Anat/Pharm
Sixth year	0	3	3	0		1	
Extra-curricular	5	9	14	1	Best oral UAEU	3	1 Medical Education/OandG
2004/5	**10**	**12**	**22**	**11**		**11**	
Second year	0	4	4	1	2nd prize YES 2nd poster LIMSC	2	1 Phys/Pharm/Internal Med
Sixth year	0	2	2	4	2 x Best oral GCC	1	3 Community Medicine
Extra-curricular	10	6*	16	6	2 x Best Poster GCC	8	1 Anat/Phys 1 OandG/Phys/Biochem
2005/6	**7**	**17**	**24**	**7**		**10**	
Second year	2	8	10	1	Best poster GCC	2	
Sixth year	0	2	2	5		2	
Extra-curricular	5	7	12	1	Best oral GCC Best poster GCC	6	1 Physiology

*includes a project undertaken during the summer abroad
YES – Young European Scientists Conference, Portugal, 2006; LIMSC – Leiden International Medical Student Conference, Leiden, 2007

In terms of overall productivity, however, articles bearing FMHS student names constitute only a small proportion of the Faculty's publications. Notwithstanding this fact, peer-reviewed articles, together with the published GCC Conference abstracts in the *EMJ,* are a permanent record of a student's scholarship. This scholarship will undoubtedly strengthen residency applications, as has been alluded to by others (Rhyne, 2000; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Chongsiriwatana, Phelan, Skipper, Rhyne, and Rayburn, 2005; Wagner and Ioffe, 2005). Many of our students have been successful with their residency applications to North American institutions, where competition is fierce. We would like to believe that their research experience and scholarship have contributed.

B. What other scholarship is associated with student research?

Developing a community of learners who are able to critically appraise the literature, generate and test hypotheses, confidently make public their findings and contribute to the knowledge base of a discipline, would undoubtedly prepare students for life-long learning and a practice of medicine based on the best available evidence. In addition, with guidance and mentoring from their supervisors, some of these young students may be encouraged to become the much needed scientific and clinical researchers of tomorrow (Association of American Medical Colleges, 2001; Zier and Stagnaro-Green, 2001; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Adderly-Kelly, 2003; Friedrich, 2003; Schor, Troen, Kanter and Levin, 2005; Wagner and Ioffe, 2005; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005; Gallin and

LeBlancq, 2005). The undergraduate research assistant programme in Brazil is an excellent example of successful 'pipelining' of undergraduate students into research careers, with state funding viewed as important in nurturing these valuable national assets (Silva, da Cunha Aguiar, Leta, Santos, Cardosa, Cabral, Rodrigues and Castro, 2004). In addition, these undergraduate research assistants have contributed to Brazilian research scholarship, with at least 61% having authored or co-authored publications.

In reviewing an extensive literature on undergraduate student research spanning several disciplines for this submission, a key feature that emerged in terms of promoting scholarship is *quality supervision* and *mentoring* (Boyer Commission, 1998; Morrison-Beedy, Aronowitz, Dyne and Mkandawire, 2001; Adderly-Kelly, 2003; Silva, da Cunha Aguiar, Leta, Santos, Cardosa, Cabral, Rodrigues and Castro, 2004; Aslam, Shakir, and Qayyum, 2005; Chongsiriwatana, Phelan, Skipper, Rhyne, and Rayburn, 2005; Crowe, 2006). Young undergraduate students who become involved in research as neophytes require technical training, as well as socialization into a culture of research. Their passion for discovery needs to be ignited and fuelled by enthusiastic mentors, supervisors, advisors and role models. This requires faculty time and dedication. At Xavier University, where research is used as a learning tool to foster enthusiasm for learning, Crowe (2006) writes about a "teacher-scholar campus" and "creative scholarship", forged by close relationships between learners and their mentors. Similarly, the success of the Brazilian undergraduate student research assistant programme (and hence its contribution to scholarship) is ascribed to the dedication of the laboratory advisors (Silva, da Cunha Aguiar, Leta, Santos, Cardosa, Cabral, Rodrigues and Castro, 2004). As inspirational leaders and mentors providing a conducive working environment and who willingly share their experience, they have motivated many young Brazilian researchers to become graduate research students. Furthermore, if Chongsiriwata and colleagues (2005) are correct, mentoring young students during their research projects, especially during the preclinical years of medicine, could increase the probability of students entering that specialty as residents. Thus, faculty members who supervise student research also demonstrate scholarship. As scholars in their respective fields (e.g. reviewers for journals or grant-holders), their guidance and mentoring of young students should be judged as evidence of *reflective critique* (University of Ottawa, 2001).

C. Are there benefits for Faculty who promote student research?

Appointment, tenure and promotion at higher institutions of learning have traditionally depended on research scholarship (Boyer Commission, 1998; Adderly-Kelly, 2003). While other forms of scholarship (teaching; administration; service) are increasingly being recognised and rewarded (Trigwell, Martin, Benjamin and Prosser, 2000; Fincher, Simpson, Mennin, Rosenfeld, Rothman and McGrew, Hansen, Masmanian, and Turnbull, 2000; Dewey, Friedland, Richards, Neela, and Kirkland, 2005), research is generally still a priority at institutions of higher learning. It therefore makes academic sense for faculty members who are themselves scholars of research to promote a scholarship of discovery amongst their students. If students are appropriately trained and supervised, supervisors will then have time for grant applications and manuscript writing (Morrison-Beedy, Aronowitz, Dyne and Mkandawire, 2001). The relationship between student research and supervisor should therefore be viewed as mutually beneficial, with rewards for both partners.

D. Can scholarship and productivity be improved?

While our audit revealed that many FMHS students have presented their results at local and international conferences, much of their work has not been followed through to what might be considered the ultimate test of scholarship: *publication in peer-reviewed journals*. This finding was surprising, considering that student research has financial (e.g. experimental animals and laboratory costs) and resource (e.g. energy and time on the part of the supervisor) implications. To remedy this, we recommend that, where possible, first year students volunteering for the summer research programme continue their project into the second year, effectively extending their research time by 4-6 weeks. While this generates more meaningful data, it does require students to be proactive in approaching potential supervisors and obtaining ethical approval. Alternatively, since summer research is voluntary, and some students may have to spend time with their families in other Emirates, several groups of second year students can be assigned to different aspects of the same project. Their collective results may then deserve publication. Zimmer (2007), a professor in Chemistry at Connecticut College, highlighted some of these suggestions in an article entitled *"Guerilla puzzling: A model for research"*. He describes how academics at undergraduate colleges, with very little additional funding, can, through "effective guerilla puzzlers", capitalize on student research by assigning them projects on the borders or "corners" of a new puzzle or to emerging areas in established research. In this way, new research questions may arise or "loose ends" may be tied up for the researcher. At the same time, students are involved in excellent learning experiences. Publication or no publication, the outcomes of such an approach reflect positively on the academy, generally without incurring major expenses. In response to Zimmer's article, Hinnefeld (2007) reminds us of the power of collaborative research. Using a similar analogy, he advocates a *"Mongol horde model",* in which scientific research is undertaken as a team: faculty members and undergraduate students from different institutions gather for an intensive period of research at a national facility. Information technology then allows team members to stay connected and to pursue the research further.

The idea of fellowships to foster undergraduate research is gaining momentum at US medical colleges (Zier and Stagnaro-Green, 2001; Gallin and LeBlancq, 2005). Students with a keen interest in science or clinical research can suspend their studies for a year or two to concentrate on research. The Doris Duke Clinical Research Fellowship, launched in 2000 at ten US medical schools, is an excellent example. From exit interviews with the first three classes of graduates, 97% of fellows felt that participating in the programme had been a good decision. More importantly, a commitment to a career in clinical research increased amongst those fellows who had initially reported being unsure at the outset of their fellowship (Gallin and LeBlancq, 2005). With some clinical disciplines reporting a lack of researchers (Association of American Medical Colleges, 2001; Friedrich, 2003), an intense period of research early in students' medical studies might "pipeline" them into a career in clinical research (Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005; Gallin and LeBlancq, 2005).

Medical student research need not be restricted to the classical laboratory- or hospital-based studies. An increased emphasis on primary health care and community-based medicine requires more generalists and family practitioners. Zorzi and colleagues' (2005) Rural Summer Student Programme for Year 1 and 2 students successfully married clinical experience and research in rural Australia. Not only did this programme promote scholarship (conference attendance and publications), but it also stimulated interest in rural health, a much neglected area of health care. Gonzales and colleagues (1998) have also reported positive outcomes in terms of

undergraduate primary health care research through the Family Medicine Scholars Programme at the University of Colorado.

III. Final comments.

Recognising that research is important in preparing today's medical graduates for tomorrow's practice, the FMHS provides undergraduate medical students with many opportunities for research, including international exposure for those who have excelled. Student research activities in the Faculty have been identified by an External Advisory Board as a valuable component of the curriculum - *"Involvement of the medical students in research is impressive. Continuation of this programme is highly encouraged"* (FMHS External Advisory Board, 2005). We are of the opinion that student research experiences, *albeit* under supervision, have contributed to the research scholarship of our Faculty. Both the *process* and the *products* of their endeavours meet the published standards of scholarship. Faculty members, as the guardians of student research, would then be rewarded for their investment of time, energy and resources. If supervised appropriately, student research can culminate in additional publications, thereby contributing to promotion, contract renewal or tenure. The academy's reputation ultimately prospers.

We must, however not lose sight of our overarching goals as teachers in Higher Education: *to improve student learning and to prepare students for the challenges they will face in their future careers*. Not only should the research experience (and the associated scholarship) of our students provide them with a competitive edge in their residency applications abroad, but they will also have experienced first-hand how new knowledge is developed and how evidence can be used to inform clinical practice. As supervisors, faculty members have introduced students to the requirements of conducting research and interpreting results, but they have also fostered the development of skills (e.g. organizational; critical thinking) necessary for life-long learning (Remes, Helenius and Siniaari, 2000; Frishman, 2001; Whittle and Murdoch-Eaton, 2001; 2002; Murdoch-Eaton, Ellershaw, Garden, Newble, Perry, Robinson, Smith, Stark, and Whittle, 2004; Joubert, 2006). These skills, we believe, will assist students with the remainder of their studies, as well as in their professional practice. Our students have confirmed this. During the past academic year, a pair of second year FMHS students investigated senior students' perceptions of their research experience on the development of transferable skills (e.g. information technology, data management, organizational), and the impact of research on their studies and future practice. There was consensus. Research had developed useful skills and had provided students with different perspectives about their chosen career in medicine. Students at other institutions have similarly recognised the importance of research in developing critical appraisal, analytical and information literacy skills (Jacobs and Cross, 1995; Frishman, 2001; Houlden, Raja, Collier, Clark and Waugh, 2004; Joubert, 2006). Finally, as others have also reported (Segal, Lloyd, Houts, Stillman, Jungas and Greer, 1990; Rhyne, 2000; Solomon, Tom, Pichert, Wasserman and Powers, 2002; Chongsiriwatana, Phelan, Skipper, Rhyne, and Rayburn, 2005; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005), our students perceive that their research experience will strengthen their residency applications to North American institutions.

Our audit of undergraduate research revealed that whilst our students' research meets with the published standards of scholarship, their contributions need to be harnessed to a greater extent, such that productivity matches the human and financial investment. Increased output can be achieved by integrating extra-curricular and mainstream research, by assigning more than one

group of students to a research project or perhaps by offering interested students a year of intensive research during their medical studies.

It is our belief that by promoting a *scholarship of research* amongst our students at the outset of their studies, we are providing the foundations for a more critical approach to learning, as well as developing inquisitive clinicians who challenge the *What?* and *Why?* of medicine. This should ultimately translate into a more informed clinical practice. What students are capable of learning in the future is just as important as how much they know when they graduate. The ability to adapt to new challenges and to solve problems as they arise is essential. We agree with Gonzalez (2001) that research experience enhances this capacity.

The information explosion of the past few decades has hastened the paradigm shift in Higher Education from a knowledge- to an inquiry-based pedagogy. A research-focused curriculum, in which students learn by doing, as advocated by John Dewey about a century ago, allows the development of skills and knowledge that become personally meaningful for students. The earlier this happens, we believe, the better. While the first few years of university study are the most formative, they are generally the least satisfactory for learners in terms of curriculum and pedagogy (Boyer Commission, 1998). We therefore owe it to our young students to socialise them into communities of practice where the scholarship of discovery is valued. Scholarly activities such as paper or poster presentations at student-led fora may also enhance students' transition into their professional practice role (Sevean, Poole and Strickland, 2005). Since "*research and learning as partners in an integrated environment across the university is a way both to improve the value of a university education and to instill a culture of innovation"* (Hanson, 2006) and because *"the skills of analysis, evaluation, and synthesis will become the hallmarks of a good education, just as absorbing a body of knowledge once was"* (Boyer Commission, 1998), research should be integral to every undergraduate university programme.

For some students, their research experience may serve as a springboard for a research career. This is particularly crucial for medicine, where there is concern over declining numbers of clinical researchers (Association of American Medical Colleges, 2001; Friedrich, 2003; Halpain, Jeste, Trinidad, Wetherell and Lebowitz, 2005; Gallin and LeBlancq, 2005). In many developing countries, where health care research is generally not a high priority in medical schools, students nevertheless view themselves as critical to the future of clinical research (Aslam, Shakir and Qayyum, 2005). With accumulating evidence that undergraduate research experience is a good predictor of career achievements (i.e. scholarship) in academic medicine (Segal, Lloyd, Houts, Stillman, Jungas and Greer, 1990; Brancati, Mead, Levine, Martin, Margolis, and Klag, 1992; Remes, Helenius and Siniaari, 2000; Reinders, Kropmans and Cohen-Schotanus, 2005), research should be included in every medical student's studies. Perhaps one day all undergraduate curricula will compare with psychology teaching, in which *"the role of research as a teaching tool appears fixed on the landscape*" (Kierniesky, 2005).

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