Bridging the Gap Between Innovation and Medical Curricula

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Categories: Curriculum Planning, Educational Strategies, Students/Trainees, Teaching and Learning, Undergraduate/Graduate

Abstract

Introduction:
The rapid advance of technology and a complex regulatory landscape have created an opportunity and need for trained physician-innovators and entrepreneurs.

Methods:
Student interest was gauged through surveys sent to various university departments while communication networks were developed by meeting with local and university-associated resources.

Results:
After gauging interest and identifying local resources, a medical school course was developed. The interest-gauging survey was completed by 284 University of Florida undergraduate students, 16 post-baccalaureates, 40 medical school (MS) 1s, 18 MS2s, 11 MS3s, and 6 MS4s. The level of interest in having innovation incorporated into the medical school curriculum was significant among undergraduates, post-baccalaureates, and medical students. The highest was among post-baccalaureates, with an 88% positive response rate, whereas MS2s had the lowest at 67%. Many potential lecture topics garnered support. Finance and Wealth Management was preferred by medical students, and biomedical engineer students preferred patent law. Core competencies such as Law/Regulation, Business, and Design/Prototyping were identified in local resources and incorporated into the course.

Discussion:
The development of this course helps bridge the gap between innovation and medicine as medical students will be trained in the innovation process. Future studies should assess lessons learned, best practices, and student satisfaction.
Keywords: Curriculum; Medical schools; Medical students; Mentors; Surveys and Questionnaires

Introduction

The United States has become a leader in medical innovation, highlighted by the fact that America is responsible for creating 40% of the world’s medical devices and advances, which comprise an estimated $350 billion global industry (PwC Medical Technology Innovation Scorecard, 2011). This industry dominance fosters a culture of innovation within the healthcare setting. Innovation differs from discovery and invention in that it comprises additional steps toward commercialization (McCarthy, 2017). The complexity of these steps is often unknown or unclear to physicians and medical personnel, thus creating a gap between innovation/invention and medicine. Translating ideas into practical and applicable technology within the context of clinical practice is a challenging but necessary undertaking to advance the medical field. The need for clinicians who are able to navigate the gap between physicians and engineers is increasing. Those individuals can facilitate an environment of invention and innovation that is favorable to improving healthcare. Medical curricula that address the invention, discovery, and innovation knowledge gaps in medical training provide a convenient starting point for developing physicians that can innovate in complex and multifaceted environments, given that this typically requires attributes beyond clinical reasoning skills.

Innovation-centered programs have been identified among many U.S. allopathic medical schools (Niccum et al., 2017). These programs are a means to address the aforementioned medical students and subsequent physicians who previously have not had exposure to the design process. By analyzing other schools’ best practices, in addition to identifying local resources and student feedback, we developed the Business and Innovation in Medicine (BIM) Discovery Track: an innovation-focused pathway grafted onto the regular medical school curriculum to foster innovation in medical students at the University of Florida (UF) College of Medicine (COM).

Methods

Survey and assessment of student interest
To both gauge student interest in an innovation curriculum and acquire constructive feedback on the topic, we developed three surveys that were distributed to UF medical students, undergraduate pre-medical students, and biomedical engineering students. The surveys addressed previous student exposure to steps in innovation and historical interest in an innovation-based curriculum. The surveys were distributed through various listservs at UF. Data collection was executed using Google Forms.

Networking
We used pre-existing university and community resources to facilitate opportunities for medical school students to get involved in innovation. Meetings were held with various university departments and offices, including: UF J. Crayton Pruitt Family Department of Biomedical Engineering (BME), Engineering Innovation Institute (UF Herbert Wertheim College of Engineering), UF Warrington College of Business, Exactech Inc., UF Innovation Hub, UF Sid Martin Biotechnology Incubator, Office of Technology and Licensing (UF Office of Research), and Office of Operational Effectiveness (UF Shands Hospital). The purpose of these connections was to create collaboration between local resources and the BIM Discovery Track. These connections allow curriculum participants to learn about and tap into the resources at their disposal for idea development and implementation. We also gathered information on interest level among faculty, topic-specific lectures, and overall input concerning the development of BIM.

An essential component of the resources used for the BIM track was the Department of BME. We developed a
partnership with the faculty to allow collaboration with and inclusion of BME students into the track. This ensured BME representation in the curriculum and produced an integrative focus between the UF COM and UF BME.

Results/Analysis

Level of interest
The survey results assessing potential interest in the BIM track are shown in Table 1. When asked about their current level of understanding in regard to commercialization and idea development, third year students (MS3) were the most informed, but they represented only a modest 27% of their class. Fourth year medical students (MS4) reported feeling the most uninformed. The level of interest in having innovation incorporated into the medical school curriculum was significant among UF undergraduates, post-baccalaureates, and medical students. The highest was among post-baccalaureates, with an 88% positive response rate. Similarly, a large proportion of surveyed students favored exposure to topics concerning business and innovation during medical school rather than during residency or while practicing as a physician. When queried about working on a team of engineers and medical students during medical school with a focus on developing an innovative idea, an overwhelming majority responded favorably. The survey was completed by 284 UF undergraduate students, 16 post-baccalaureates, 40 MS1s, 18 MS2s, 11 MS3s, and 6 MS4s.

Table 1. Survey results from University of Florida undergraduates and medical students concerning interest in the business and innovation discovery track

| Survey question                                                                 | UF undergraduate | Post-bac/other | MS1 | MS2 | MS3 | MS4 |
|---------------------------------------------------------------------------------|------------------|----------------|-----|-----|-----|-----|
| Current understanding of commercialization and idea development                 |                  |                |     |     |     |     |
| Very well informed                                                             | –                | –              | 3%  | 17% | 27% | 0%  |
| Somewhat informed                                                              | –                | –              | 38% | 28% | 27% | 17% |
| Uninformed                                                                      | –                | –              | 60% | 56% | 45% | 83% |
| Level of interest in innovation incorporated into the medical school curriculum |                  |                |     |     |     |     |
| 83%                                                                             | 88%              | 73%            | 67% | 82% | 83% |
| When would you like to be exposed to topics concerning business and innovation (patents, business start-ups, etc.) during your medical education? |                  |                |     |     |     |     |
| Medical school                                                                  | 82%              | 94%            | 83% | 72% | 91% | 83% |
| Residency                                                                       | 8%               | 6%             | 13% | 28% | 9%  | 0%  |
| Attending                                                                       | 6%               | 0%             | 3%  | 0%  | 0%  | 17% |
| Never                                                                           | 5%               | 0%             | 3%  | 0%  | 0%  | 0%  |
| Level of interest in working on a team of engineers/medical students during medical school focused on developing an innovative idea |                  |                |     |     |     |     |
| 85%                                                                             | 88%              | 73%            | 61% | 82% | 83% |
| Total number of respondents                                                     | 284              | 16             | 40  | 18  | 11  | 6   |

Popular topics of interest
A significant number of medical students and BME students expressed interest in the following topics: Food and Drug Administration regulations, Patent Law, Introduction to Entrepreneurship, Ethics in Innovation, Finance and Wealth, Management, Introduction to Biomedical Engineering, and advice from local entrepreneurs (Figure 1). Finance and Wealth Management was the most popular topic among medical students (72%), whereas Patent Law was the most favored among BME students (59%). The topic of Food and Drug Administration regulations received the most consistent support among undergraduates, post-baccalaureates, medical students, and BME students. Unsurprisingly, there was little support among BME students for an Introduction to Biomedical Engineering topic despite favorable responses from the other students.
BME students were also surveyed to gauge their interest in collaborating with medical students as part of the BIM curriculum (Table 2). This survey included responses from 35 sophomores, 45 juniors, and 34 seniors currently enrolled in the BME Department. A large majority of students (71% of sophomores, 79% of juniors, and 71% of seniors) supported the idea of working on a team of engineers and medical students for class credit or during free time. Support was also found when students were asked about enrolling in a class shared with medical students and other engineering students, as 89% of sophomores, 93% of juniors, and 91% of seniors reported being at least somewhat interested. There was only minor agreement that a course similar to our BIM course would influence their decision between undergraduate or graduate engineering schools.

Table 2. Survey results from biomedical engineering students at the University of Florida gauging interest in the business and innovation discovery track

| Survey question                                                                 | 2nd Year | 3rd Year | 4th Year |
|--------------------------------------------------------------------------------|----------|----------|----------|
| Would you be willing to work on a team of engineers/medical students with a focus on developing an innovative idea in either a class for credit or on your own time? | Either 71% | 79% | 71% |
|                                                                                  | Only for class credit 11% | 5% | 24% |
|                                                                                  | Only during my free time 17% | 16% | 0% |
| What would be your level of interest in enrolling in a class shared with engineering and medical school students? | Very interested 51% | 68% | 62% |
|                                                                                  | Somewhat interested 37% | 21% | 29% |
|                                                                                  | Neutral 11% | 5% | 5% |
|                                                                                  | Uninterested 0% | 5% | 5% |
| Would an engineering elective pertaining to "Business and Innovation in Medicine" that was shared with students from the College of Medicine influence your decision between undergraduate/graduate engineering schools? | Yes 34% | 32% | 52% |
|                                                                                  | No 31% | 32% | 24% |
|                                                                                  | Neutral 34% | 37% | 24% |
| Total number of respondents                                                      | 35 | 19 | 21 |

Core educational competencies

While developing our BIM track, we used several partnerships, including university departments and their faculty resources, local community businesses, and hospital affiliations as conduits to incorporate the track’s core...
competencies (e.g., Law/Regulation, Business, Design/Prototyping), as represented in Table 3. All partnerships included at least two of the BIM track’s core competencies. Our most commonly used partnership were the various university colleges/departments: BME, Business, Engineering, Law, and Medicine. Of note, BME incorporated all three core competencies, while the Engineering Innovation Institute incorporated two (Law/Regulation and Business) of the three core competencies. In our case, the Law/Regulation core competency was most heavily emphasized using our university resources. The Business core competency was distinctively integrated into the track using local community businesses such as Exactech Inc. and other start-ups. The Design/Prototyping core competency was used throughout most partnerships, and most notably, our hospital affiliation (i.e., UF Health) heavily focused on this competency.

Table 3. The core competencies of the various local and University of Florida resources

| Partnerships                                      | Core Competency |             |             |
|--------------------------------------------------|-----------------|-------------|-------------|
|                                                  | Law/Regulation  | Business    | Design/Prototyping |
| **University Departments**                       |                 |             |              |
| J. Crayton Pruitt Family Department of Biomedical Engineering | ✓               | ✓           | ✓            |
| UF Warrington College of Business                |                 | ✓           |              |
| UF Herbert Wertheim College of Engineering       |                 |             | ✓            |
| UF Levin College of Law                          | ✓               |             |              |
| UF Engineering Innovation Institute              | ✓               | ✓           |              |
| UF College of Medicine                           |                 |             | ✓            |
| **University Resources**                         |                 |             |              |
| UF Sid Martin Biotechnology Incubator            | ✓               | ✓           |              |
| UF Innovation Hub                                | ✓               |             | ✓            |
| UF Office of Technology Licensing                | ✓               |             |              |
| Gator Hatchery                                   |                 |             | ✓            |
| **Community Resources**                          |                 |             |              |
| Local Entrepreneurs                              | ✓               |             | ✓            |
| Start-up GNV                                     |                 |             | ✓            |
| **Health System Resources - UF Shands**          |                 |             |              |
| Physician Innovators                             |                 |             | ✓            |
| UF Health Clinical and Translational Science Institute |             |             | ✓            |
Program structure

The BIM course is among many Discovery Tracks at the UF COM that allows for extensive individual curriculum customization. A full curriculum outline is shown in Figure 2. Medical students of all years are permitted to enroll in the course; however, course optimization would entail a first year medical student’s enrollment during the first semester of medical school. All of the BIM track requirements can be completed in 3 years by shortening the Design/Prototyping period. The four-year longitudinal option begins during MS1 with a series of introductory and foundational lectures and seminars, which we term "Session A" of our track. This phase stems from the probability that our track’s participants will have diverse educational backgrounds and thus varying levels of engineering-, innovation-, and business-related acumen. Therefore, Session A was designed to provide standardized and minimally required knowledge for the following "Date Night" event and subsequent sessions. Date Night will bring together physician-innovators and students in a "meet and greet" environment to allow facilitation of ideas and present possible Capstone Projects to the students. Session B will take place during the following semester (2nd semester) and will comprise lecture topics that facilitate student development within the realm of innovation. Session C will continue during Year 2 of medical school. Of these lectures, an attendance of 75% is required. BIM lectures will also include guest seminars from local entrepreneurs and physician-innovators. Students are presented optional, yet recommended, sit-ins during BME lectures within their "Clinical Correlations" course, which exposes BME students to clinical problems. This course is an additional component to the track that allows for interdisciplinary communication. The Medical Student Research Project (MSRP) will also be available for BIM-specific research during the summer between MS1 and MS2. The MSRP program is a UF COM sponsored program that allows medical students to participate in research while being funded by UF. By incorporating MSRP into the BIM curriculum, valuable protected time is available for the development of ideas and can serve as the beginning of a Capstone Project.

Figure 2: Timeline demonstrating the component of the Business and Innovation Discovery Track. MSRP, medical student research project; UF, University of Florida; IRB, Institutional Review Board.
After Date Night, the recruitment (Build Team) and Design/Prototyping phase begins, which runs to the completion of the track. This phase allows for medical students to form an interdisciplinary team of engineers, business majors, graduate students, etc. This team will work to take on an existing or identify a new clinical problem and design a solution. The team’s progress will be developed into a required Capstone Project that will be presented at the end of the course for evaluation.

The Date Night milestone is an event consisting of an allotted time for track participants and a curated listing of investigators, physicians, and entrepreneurs who have current endeavors or ideas for potential innovative and entrepreneurial projects to discuss potential involvement, contributions, and responsibilities. This serves as a catalyst for our students to begin forming their Capstone Projects and provides a gateway to incorporating Capstone-related elements as early as the MSRP period.

Although our track is intended to be a longitudinal 4-year curriculum, students may opt to begin at the beginning of MS2. These students will enter at Year 1 and continue through Year 3 (Year 4 will not be available, as these students will have graduated). Unfortunately, a later start to the track will come at the expense of the aforementioned Date Night and less time and preparation for completion of a Capstone Project.

Discussion

The goal of a BIM program is to create a pipeline for medical students to receive education on medical innovation. Through exposure to a wide variety of topics ranging from intellectual property protection to the creative design process, participants are provided with the basics on how to pursue a career as a physician innovator. These skills will be valuable in the increasingly dynamic and innovation-oriented setting of healthcare in the United States. The demands of today’s healthcare setting mandate the need for interdisciplinary collaboration and expertise while also challenging the way in which physicians are trained (Krummel et al., 2006). To this end, innovation and entrepreneurship (I&E) programs are becoming more prevalent and have already begun to make an impact in healthcare (Niccum et al., 2017). After a survey verified there was an adequate local BIM track demand in the UF COM, we developed a curriculum informed by previous descriptions that summarize what other U.S. allopathic I&E programs are doing (Niccum et al., 2017).

Surveys administered to students in the UF COM, undergraduate pre-medical students, and BME students revealed several trends. Importantly, we found that while very few of our potential BIM track members consider themselves well versed in I&E topics, a majority of them were enthusiastic about participation in an I&E curriculum. It is encouraging that many of the engineering students surveyed were also excited about and saw value in working with medical school students on engineering-oriented Capstone Projects. These surveys are in line with the trend of enthusiasm for and development of I&E programs, with 52% of MS4s responding that the program would influence their decision regarding where to attend medical school (Jeyabaladevan and Yogalingam, 2018).

Once we had identified the interest in developing an I&E program at UF, we proceeded to form collaborations across disciplines and tap into the huge network of expertise and resources across the university. This has been done at several other I&E programs in the country and is commonly referred to as a strength of these programs (Cohen, 2017). For engineering expertise, we partnered with various engineering departments across the institution, with emphasis placed on BME due to the very similar needs of BME and medical school student innovators. Medical, legal, and regulatory expertise was acquired through collaboration with the Office of Technology Licensing, the law school, and lecturers from the Department of BME. Business and entrepreneurship expertise were incorporated through collaboration with the business school at UF, local entrepreneurs, and collaboration from various incubator/start-up organizations specific to UF. Mentorship for our students was found through networking with
both the university health system and with engineering professors in the Department of BME. It is worth noting that once we began to tap into the network within our institution, a vast array of opportunities and referrals to other resources began to take place, helping us to capture many different and unforeseen partnerships.

After we had assembled and established partnerships around the university, we constructed a timeline centered around the UF medical school curriculum, feedback, and the availability of lecturers/mentors, and based on what has worked for other schools. Emphasis was placed on longevity in order to maximize time for the development of a Capstone Project while participating in the track. In our track, students are immersed during their first year in essential lectures that build the foundation for them to engage in meaningful conversation with potential project mentors by the end of their first semester. Their second semester of medical school focuses on identifying mentors during speed dating (Date Night), assembling interdisciplinary teams, and acquiring funding/institutional approval for projects. This model allows students to use their first summer to make significant progress in their Capstone Projects and leaves fewer essential lectures to take place in tandem with the projects during their second year. As an option, the track allows for students in their second year to join the track, at the expense of time they could have devoted to their Capstone Projects. By the fourth year in the curriculum, students have integrated time to present their results and future directions. This model mirrors those at other I&E programs in the country and fits nicely with our own schools' medical curriculum (Brown Alpert Medical School, Office of Medical Education; Thomas Jefferson University).

The model used for our BIM track allows for longitudinal experiences in the innovation process. Our track is built around our medical school's curriculum and is flexible enough to allow students to join on an ongoing basis. Furthermore, it capitalizes on already existing departments and resources while also developing several interdisciplinary collaborations across the university. We hope that our own experiences and decisions while developing the BIM track can help provide a general model for how future I&E-oriented programs are put in place.

A limitation in our results is the possibility of bias in our survey results, as students interested in this course are more likely to respond, while uninterested students are less likely to engage. This has the potential to produce falsely elevated support.

**Conclusion**

Overall, this study represents our work developing the UF BIM track through combining local resources and strengths within the context of what is being done nationally and with appreciation for the limitations of our own students' schedules. With the support of the students and faculty, we created a curriculum to satisfy the increasing demand for physician innovators. In the future, we hope to further contribute to the development of I&E programs at other schools through the assessment and refinement of our own.

**Take Home Messages**

- We identified an interest in developing an innovation and entrepreneurship program at the University of Florida and formed collaborations across disciplines in our institution, which opened up an array of opportunities and referrals to other resources.
- Our track is built around our medical school's curriculum and is flexible enough to allow students to join on an ongoing basis.
- Our track can serve as a model for other institutions to combine local resources with institution-wide resources to satisfy the increasing demand for physician innovators.
Notes On Contributors

Kyle W. Scott is a medical student at the University of Florida College of Medicine, Gainesville, Florida.

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Acknowledgements

The authors would like to extend their most sincere gratitude to the program directors that contributed to this study. The authors would also like to thank Corey Astrom, ELS, for her editorial expertise and assistance with this manuscript.

Findings of current study were presented at:

1. Scott, K.W., Trumbull, D.A., Zaldivar, J., Arias, J., Sharma, B., Allen, K., Gravenstein, N., *Development of an Innovation-focused Course in a Medical School Curriculum*. Poster presentation. Innovations in Medical Education Conference. 14 February 2020. Los Angeles, CA.

2. Trumbull, D.A., Scott, K.W., Zaldivar, J., Arias, J., Gravenstein, N., *How to develop physician-innovators in medical school*. Poster Presentation. American Physician Scientists Association South Atlantic Medical Scientists Annual Meeting. 19 October 2019. Gainesville, FL.

Figures 1 and 2: Source: the authors.

Bibliography/References

Brown Alpert Medical School, Office of Medical Education. (n.d.) *Scholarly Concentration in Medical Technology, Innovation and Entrepreneurship*. Available at: https://www.brown.edu/academics/medical/education/scholarly-concentration-program/medical-technology-innovation-and-entrepreneur (Accessed: 28 Nov 2019).

Cohen, M. S. (2017) 'Enhancing surgical innovation through a specialized medical school pathway of excellence in innovation and entrepreneurship: Lessons learned and opportunities for the future', *Surgery*, 162(5), pp. 989–993. https://doi.org/10.1016/j.surg.2017.06.012
Jeyabaladevan, P. and Yogalingam, S. (2018) ‘A call to reform medical curricula to sustain the NHS,’ *Medical Education Online*, 23(1), 1530560. [https://doi.org/10.1080/10872981.2018.1530560](https://doi.org/10.1080/10872981.2018.1530560)

Krummel, T. M., Gertner, M., Makower, J., Milroy, C., *et al*. (2006) ‘Inventing our future: Training the next generation of surgeon innovators’, *Seminars in Pediatric Surgery*, 15(4), pp. 309–318. [https://doi.org/10.1053/j.sempedsurg.2006.07.011](https://doi.org/10.1053/j.sempedsurg.2006.07.011)

McCarthy, D. P. (2017) ‘Fostering a culture of innovation in academic surgery’, *Surgery*, 161(4), pp. 892–896. [https://doi.org/10.1016/j.surg.2016.08.035](https://doi.org/10.1016/j.surg.2016.08.035)

Niccum, B. A., Sarker, A., Wolf, S. J., and Trowbridge, M. J. (2017) ‘Innovation and entrepreneurship programs in US medical education: A landscape review and thematic analysis’, *Medical Education Online*, 22(1), 1360722. [https://doi.org/10.1080/10872981.2017.1360722](https://doi.org/10.1080/10872981.2017.1360722)

PwC. (2011) *Medical Technology Innovation Scorecard*. Available at: [https://www.pwc.com/il/en/pharmaceuticals/assets/innovation-scorecard.pdf](https://www.pwc.com/il/en/pharmaceuticals/assets/innovation-scorecard.pdf) (Accessed: 14 Sept 2019).

Thomas Jefferson University. (n.d.) *Scholarly Inquiry Tracks*. Available at: [https://www.jefferson.edu/university/skmc/undergraduate-medical-education/curriculum/Scholarly-Inquiry/Scholarly-Inquiry-Tracks.html](https://www.jefferson.edu/university/skmc/undergraduate-medical-education/curriculum/Scholarly-Inquiry/Scholarly-Inquiry-Tracks.html) (Accessed: 28 Nov 2019).

### Appendices

None.

### Declarations

_The author has declared that there are no conflicts of interest._

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### Ethics Statement

This study is focused on quality improvement; as a result, it was deemed exempt by our Institutional Review Board at the University of Florida. The research was conducted in accordance with the Declaration of Helsinki.

### External Funding

This research was supported by the Jerome H. Modell Endowed Professorship (N.G.).

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