A STUDENT-DRIVEN COURSE BRINGS MEDICAL STUDENTS INTO THE INNOVATION ARENA

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ABSTRACT

Medicine is an area teeming with opportunities for innovation. However, medical education remains focused on the memorization of large volumes of information rather than cultivation of critical thinking skills. Students who enter with aspirations of service-learning or device development have no outlet for these passions. For these reasons, students at the University of Texas Southwestern Medical School created and have been running a health innovations course called Innovating Healthcare Solutions (IHS) to instruct students in the design process as they create projects to improve health outcomes in partner communities within Dallas and abroad. Over the past few years, this course has developed into a year-long program with faculty and administrative support from within the medical center and also from partner university engineering programs. Student projects created during the course have impacted healthcare within Dallas and also within partner communities abroad, demonstrating the value of design education within the medical school curriculum.

Introduction

The University of Texas Southwestern Medical Center (UTSW) is one of the leading medical education and biomedical research institutions in the United States, and its mission emphasizes education and innovation. The major teaching hospital affiliated with the university, Parkland Memorial Hospital, is the public hospital for Dallas County and one of the largest teaching hospitals in the nation. Parkland holds a strong commitment to providing quality healthcare and, in particular, fulfills a great public service in providing high quality healthcare to the indigent population in Dallas County. These strong commitments to innovation and public service made UT Southwestern an ideal place for the development of Innovating Healthcare Solutions (IHS), a student-led experiential service-learning course that aims to empower teams of medical and graduate students to creatively address unmet clinical needs in the United States and abroad.

Innovating Healthcare Solutions is a student-driven medical student elective that was developed in 2008 to help students develop the skills and mindset required to accurately assess medical problems and provide feasible solutions in a team-based environment. Students work in teams with community partners in Dallas and abroad to design products and initiative-based solutions to problems seen within these partner communities. Since 2008, the course has grown to include mechanical engineering students from the University of Texas at Arlington (UTA), as well as graduate students from other UTSW departments. The final deliverable of the course is a product prototype or community initiative to be implemented in the partner community.

Motivation for the Course

Aspiring doctors are encouraged from an early age to become deep thinkers and servants of the community. Undergraduates hoping to become doctors take challenging courses in a variety of disciplines, including engineering, and thus cultivate their creative thinking capabilities. They spend time on a number of volunteer projects, and through these activities, often encounter issues that they become deeply passionate about. They write admissions essays expounding upon their passion for medicine, science, and service, and they convince doctors across the country of their commitment to these areas for a chance to enroll in medical school and pursue their dreams. However, as they enter their first year as medical students, these passions and dreams are quickly put to the side as they tackle the daunting task of memorizing large volumes of information. Often, these students do not think critically as part of a team again until their third year of medical school although, interestingly, teamwork and critical thinking skills become more important in the day-to-day practice of medicine than many of the biochemical pathways painstakingly memorized during the first year of medical school.

In recognition of this need for change in medical school curricula, problem-based learning (PBL) has been introduced as a teaching strategy. Although initially developed in the 1970s, it did not gain traction in medical education until the 1990s (Campbell 1970; Tosteson 1990). Problem-based learning uses clinical problems as a context for students to learn problem-solving skills and acquire knowledge about the basic and clinical sciences (Albanese and Mitchell 1993). Advantages of this teaching style include fostering of clinical reasoning and promotion of interaction between students and interdepartmental collaborators (Norman and Schmidt 1992; Mennin and Martinez-Burrola 1986). However, cost limits widespread implementation, particularly at large institutions (Albanese and Mitchell 1993; Berkson 1993). At UTSW, some aspects of PBL have been implemented in small group settings, however the bulk of the curriculum follows a traditional didactic lecture format.

In addition, interest in service learning in the medical curriculum has risen in the past couple of decades (Kraft 1996). A recently adopted Liaison Committee on Medical Education (LCME) addition to medical school accreditation guidelines states that medical education programs should make sufficient opportunities available for service-learning activities and should encourage student participation in these activities. The goal of service-learning in medical education is to raise the level of immersion of student volunteers in service activities with formal curriculum and reflection, so that students can form meaningful relationships with community partners, effect social change, and allow lessons learned in service to become part of the student's professional development (Parsi and List 2008).

Innovating Healthcare Solutions (HIS) combines the objectives of PBL and service-learning education to teach medical students to be critical problem solvers while also making a social impact. Students learn a concrete process for problem solving that they can carry with them throughout their professional careers. They learn how to form teams with community partners and to immerse themselves in different cultures and situations to gain a better understanding of problems. While learning these skills, students also have an opportunity to enact social change through their ideas and designs. Course learning objectives have been created to direct the students toward these goals (Table 1).

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1 Become familiar with current problems in health care.

2 Develop relationships with community partners to define a particular problem.

3 Develop critical thinking skills to address this problem.

4 Understand the innovation process and how it can be applied to health problems.

5 Develop an effective solution to a particular problem in health care that can be implemented.

Table 1. Course Learning Objectives

Tailoring the Design Process to Medical Education

The Innovating Healthcare Solutions (HIS) curriculum was originally inspired by the experience of the course founder in MIT's D-Lab: Design course as an undergraduate. IHS adapted that curriculum to teach the design process more generally, so that it could be applied to any problem of human design, not only those problems in a traditional engineering space. The seven enrolled students were given the problem of medical illiteracy to tackle at beginning of the course and then were instructed in the steps of the design process to come up with a solution to that problem at a community free acute care clinic. They worked in collaboration with the clinic management and ultimately tested their solution with the patient population at the clinic. The course was taught over a semester and at the end of the semester, the students' solution, cards giving instructions for administration of various prescribed medications through picture symbols, was implemented in the clinic.

Since that time, the course has expanded. It now spans a full academic year, and even that seems a short amount of time to complete the process of solution development and prototyping. As a result, the problem identification portion of the process has been split off into a sister course, Clinical Needs Finding (CNF), which occurs in the summer (Figure 1). CNF trains preclinical (first/second year) medical students to systematically identify unmet clinical needs, which then serve as project prompts for IHS. IHS students are then able to select a problem to tackle at the beginning of the course from a list of well-researched needs statements generated by the Clinical Needs Finding elective. Thus, students are able to spend more time on solution generation and prototyping. In addition, students continue to partner with local free clinics, but new partnerships have been formed with physicians and surgeons within UTSW and also with communities abroad. Furthermore, a two-track model for the course has emerged. Students sort themselves into two different tracks, "Product" and "Initiative," depending on which type of solution they wish to create. The Initiative track focuses on developing and implementing health programs, while the Product track focuses on technology-based solutions. Both tracks receive instructions on the basic steps of the design process in the core curriculum (Table 2), but specialized lectures for each track are also included in the curriculum. Examples of these specialized lecture topics include business modeling, sustainability, and cultural competency. Attendance to lecture series by faculty in community medicine and global health is also encouraged for teams that may find the content relevant.
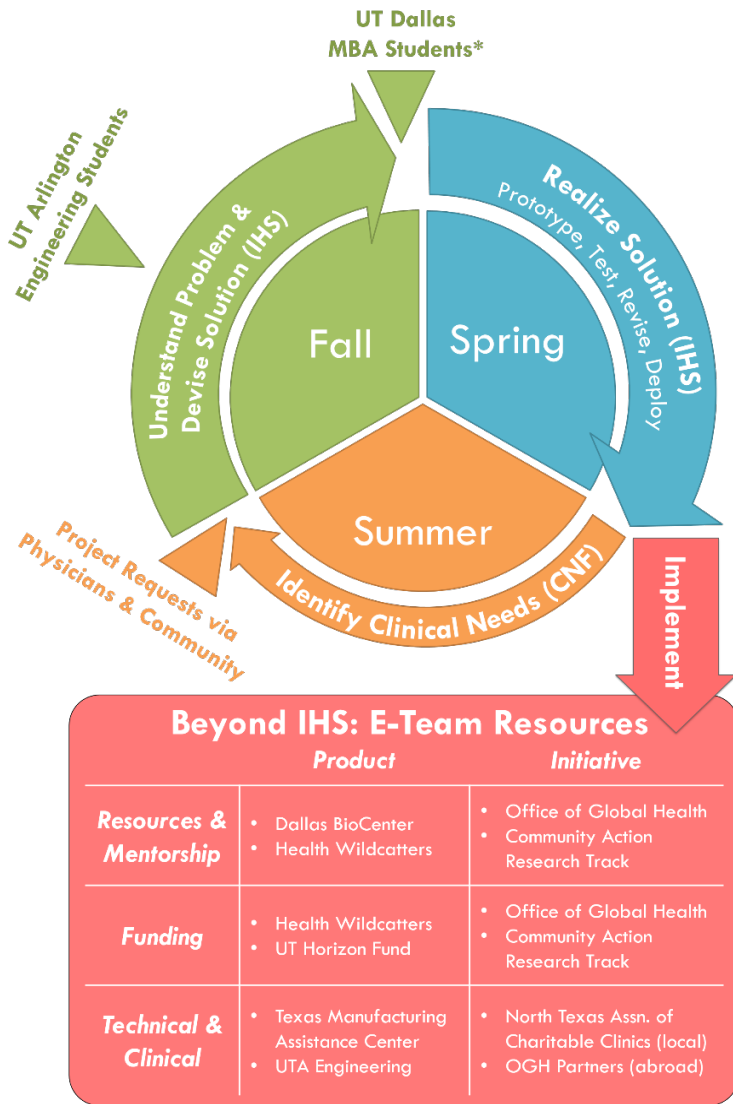
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Figure 1. Course Structure

Session	Activities	Deliverable Due
1: Aug 13	Introduction to Innovation and the Problem-Solving Process	Rank list of needs
2: Aug 20	Understanding the Problem	Team assignment survey
3: Aug 27	Idea Generation and Note-Taking	Finalized need statement
4: Sep 10	Team Dynamics and Project Planning	
5: Sep 24	Idea Evaluation	Literature/design context review, 25 brainstormed ideas
6: Oct 1	Presentation Skills and Pitching	
7: Oct 29	Mock Review	Design Review Presentation
8: Nov 19	Design Review	

Table 2. Core Curriculum

Outside of these core classes, teams meet in small groups with a Teaching Fellow, who serves as a project facilitator. Teaching Fellows are higher-level students with prior experience in the class or in product/initiative design who are invited to return and lead the course. Teaching Fellows help teams apply principles from the core curriculum to their own projects and help teams overcome obstacles in project design and in collaboration with community partners. These meetings become more frequent in the spring semester, as the focus shifts from learning core concepts to developing projects and prototypes. Teaching Fellows are also responsible for overall course management, as will be described in a later section.

IHS currently collaborates with the University of Texas Arlington (UTA) department of mechanical engineering. Students in the senior design course at UTA have the option of collaborating with IHS medical student teams on a medical device project. These students learn from their own core curriculum with UTA, but do meet with IHS students and facilitators to work on project development. Engineering students join IHS teams by Session 4, once IHS teams have decided whether they will follow the Product or Initiative track.

The final deliverable for the course is an initiative plan or product prototype to be presented at the academic year-end IHS Symposium. Students pitch their projects and model their prototypes for a panel of judges including experts in health care and in medical devices, distinguished local business representatives, and community partners. Students can then apply for funds through UTSW or other agencies to continue work on their projects.

The current suite of innovation electives, CNF and IHS, are already a critical element of several specialized education programs at UTSW. Currently, IHS is a required elective for the CART program, an MD with Distinction in Community Action & Research. In addition, IHS is offered as an elective for the MD with Distinction in Global Health, which is administered by the Office of Global Health (OGH). CART students utilizing IHS to design solutions for implementation in the developing world have the full funding and mentorship support of the OGH and CART at UTSW. Several successful devices and community health initiatives have arisen from IHS (examples of a few such projects will be discussed at a later point).

Student-Driven Course Management

Innovating Healthcare Solutions (IHS) is unique in that it was designed by students and is run by students. A team of student Teaching Fellows (TF) manages all aspects of the course. These TFs also serve as project mentors for individual teams and teach the core curriculum. TFs are typically second-year medical students who either completed the course as first-year students or who have some prior experience in device or initiative design, who are then invited to return in a leadership capacity. At present, at team of ten student facilitators manages a course of about sixty students.

The original curriculum was developed by a second-year medical student and is based on her undergraduate experience in MIT's D-Lab course. It is reviewed on a yearly basis by a subset of the course TFs and has become gradually enriched by the variety of educational experiences of these Teaching Fellows. Although it does incorporate aspects of the device design curricula at Stanford University and Rice University (among other institutions), it has come to have a unique identity as principles from these other design courses have been modified to meet the educational needs of medical students at UTSW.

The student-driven nature of the course is a source of pride for the TFs and a testament to the motivation of students at UTSW to get

out into the community and create lasting positive change. It is important to note that students do not receive grades or credit for the course, and that the course is not required. Students who enroll do so because they are truly passionate about becoming physician-entrepreneurs and enacting positive social change. The course has grown from its original cohort of seven students to a class of sixty. Teaching Fellows direct the day-to-day logistics of the course, as well as long-term planning and course expansion. This fall, the TF team applied for and was awarded an NCIIA grant to expand the reach of IHS programs.

As it increases in popularity and campus impact, IHS has attracted the attention of UTSW faculty and administration interested in empowering students to follow their passions. The course has attracted support from the UTSW Office of Global Health (OGH), the Department of Family and Community Medicine, and the Dallas BioCenter. Program faculty from these departments provide guidance for the HIS program, including didactic strategies, long-term planning, facilitator mentorship, and acquisition of funding and other resources. A challenge in the coming years will be formalizing this faculty mentorship while also maintaining the student-driven spirit of the course.

In addition to Teaching Fellows and faculty, there are a few other key team members and partners vital to successful implementation of the HIS course. For example, Project Mentors are faculty, residents, or community members with an interest in a particular project or expertise useful in the execution of a particular project. They meet with students at regular intervals during the design process to help troubleshoot and provide content expertise. Community partners of HIS include expert speakers, team mentors, and vital support for continuing projects beyond the academic course. Product teams enjoy significant support from the Dallas community. Initiative-

based projects include the support of The North Texas Association of Charitable Clinics, which provides HIS with clinical needs as well as a network of community clinics targeting local, underserved populations. Many HIS Product and Initiative teams target healthcare problems within the developing world. The UTSW OGH offers teams access to these populations via partnerships and exchanges with teaching hospitals across five continents and individual clinical mentors with networks in more than 50 countries.

Course Sustainability and Future Goals

In its initial years, funding for project design in the course was limited and came solely from community partners interested in the projects that were being designed by students. As the course became more established, administrative support has increased. At present, Innovating Healthcare Solutions (HIS) receives monetary and administrative support (including team seed funding) from CART, OGH, the UTSW Department of Biomedical Engineering, the Office of Student Affairs, and the Office of Technology Development.

Student entrepreneurship is a growing priority at UTSW, and is well supported by the North Texas entrepreneurial environment at large. The University of Texas system established the UT Horizon Fund in 2011 to support venture creation and investment competitions throughout the system's institutions, targeting innovation in information technology and medical technology. IHS is the current vehicle at UTSW for student submissions to the UT Horizon Fund.

The Dallas BioCenter, UTSW's technology incubator, provides commercialization support, including financial and legal assistance. Further, the BioCenter connects IHS teams with mentors in medical technology ventures through its partnerships with the Dallas Entrepreneur Center, the North Texas Enterprise Center, and Health Wildcatters.

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Product teams enjoy manufacturing and design support from the Texas Manufacturing Assistance Center (TMAC) and UTA. E-Teams have the option of developing their ventures beyond IHS with funding and workspace via fast-track acceptance into Health Wildcatters.

The total cost of running the course during the calendar year amounts to less then five thousand dollars. Course staffing is provided on a volunteer basis by the TFs. A small amount (around $500) per team is allotted for prototyping/project development expenses from OGH and UTA. The only other major course expenses are those involved in hosting the end of the year IHS Symposium, which are currently funded by OGH. Students interested in pursuing further implementation of projects may apply for funding from OGH or external sources.

IHS recently applied to the NCIIA for funding for a few program expansions. For example, one goal is the expansion of CNF into an elective that can also be taken in the third or fourth year of medical school. The goal is to form a continuous pipeline of clinical projects generated from ongoing clinical needs-finding. In addition, IHS aims to further expand its multidisciplinary offerings. After this pilot year with UTA, Teaching Fellows are planning to look into the possibility of expanding the course to include business students at UTD. Furthermore, IHS would create some method of recognition for the students in this course. As it is an elective, students do not receive a grade or transcript credit for their work. Those students interested in global or community health can use the experience to fulfill requirements for degrees with a distinction in global health or community action and research (CART). With an NCIIA grant, Teaching Fellows would work towards creation of a UTSW Distinction in Medical Entrepreneurship for students who complete the course.

One challenge presented by the student-driven course management is the turnover of leadership and ideas from year to year. Although some members of the present leadership board have been present since the initial development of the course, it is unlikely that this will be possible in the long run. For this reason, the Teaching Fellows have proposed the creation of a formal faculty advisory board to provide some consistency in long-term course strategy from year to year. Key faculty contributors have been invited to serve in this capacity, and the current plan is for quarterly meetings with the TF team to assess progress toward long-term goals.

Social Impact

Examples of selected Innovating Healthcare Solutions (HIS) projects follow. These projects are a small sample of those developed by student teams in the course. Although formal measures of class success have not been implemented, these projects do provide examples of how student projects have positively impacted IHS partner communities

Medication Illustration Cards

In the first year of the course, the student team explored the issue of health literacy at an IHS partner clinic, The Monday Clinic, which is an acute care clinic run by North Dallas Shared Ministries. Most patients that access clinic services are Spanish-speaking and a significant proportion of these patients are illiterate. Instructions for use of medications are given verbally and patients are not always able to remember the instructions once they go home. As it is an acute care clinic, patients also typically do not have follow up appointments. For these reasons, the students, in conjunction with graduate medical illustration students at UTSW, developed a symbol language to depict common usage instructions for medications given at the clinic. These symbols were tested with clinic patients and then used to make symbol placards dispensed with the medications at the clinic so that patients could have instructions

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for medication use at home. The cards are currently in use at the clinic.

EndoCaddy

During endovascular surgeries, multiple wires and catheters may be employed to guide the surgeon to the lesion(s) of interest. These tools may be used once, but often the wires and catheters need to be kept sterile after initial use for re-employ later in the surgery. This can create quite a hassle for the surgical team, since the wires and catheter are long, floppy, and difficult to store in a sterile fashion. The EndoCaddy is a device with a mechanism that stores the wires and catheters in a compact and sterile fashion. The device is easy to use and may be employed with one hand. It also contains a reservoir for heparinized saline to keep the catheter and wires moist while they are being stored. A physician-entrepreneur in the area is currently funding the project and the group has formed the company EndoCaddy LLC. The group is in the process of applying for a patent.

Evaluation Plan

Although the course has received positive feedback from students, community partners, and UTSW faculty and administration, the Teaching Fellows are in the process of designing an objective assessment tool to evaluate course success and impact. Formal evaluation of the course to date has come from students and has been focused on course structure and content. A number of changes to the course have been made based on these evaluations, however data collected thus far has not focused on course impact. The new assessment tool aims to evaluate IHS impact both in student education as well as social impact within partner communities. Initial, mid-year, and end-of course student surveys will be administered to understand student interest, goals, and needs and to evaluate these against student feedback, with emphasis on knowledge and skill sets gained. Program effectiveness will be measured by project outcomes for both tracks—including

the number and success of submissions to innovation competitions, grant funding, journal publications, and provisional patent applications. The impact of the course on student attitudes and clinical performance will also be assessed by examining IHS alumni career choices, student performance, and attitudes toward entrepreneurship. Community partners will also be evaluated to assess satisfaction with the course and project outcomes. Social impact will be assessed by looking specifically at projects implemented in partner communities. Metrics specific to each project will be developed to evaluate project success. Through the utilization of such objective assessment tools, the course can evaluate its progress and adapt as needed to reach long-term goals.

Conclusion

Innovating Healthcare Solutions (IHS) fulfills a need in the UTSW medical curriculum for the empowerment of future physicians to be able to identify and address unmet clinical needs creatively. Its efficacy in empowerment of students is evidenced by the growing popularity of the course on campus and the growing number of student IHS alumni who continue to show initiative in the development of their own projects and also in support of the class as a whole. As one student noted, "Seeing the energy and enthusiasm for giving was inspiring to me to continue my own projects and to continue with public outreach endeavors in the future." Students in the course will become better team players, a skill critical to effective patient care in clinical medicine. They will become better listeners and observers as they immerse themselves in the needs of partner communities. Students will learn the importance of patient, community, and stakeholder involvement in developing feasible solutions to health care problems. The skills learned by students in IHS will guide them to become physician-innovators and proactive problem solvers. These students will know how, when faced

by a large and daunting clinical problem, to break that problem into approachable pieces and to make a positive impact. Therefore, it is important to provide medical students with the opportunity to learn the design process and become innovators. It not only provides them with an outlet to express their passions and stay motivated in their studies, but also provides training in skills essential to a lifetime of successful practice of clinical medicine.

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