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Bringing cancer prevention research competencies to the classroom

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Abstract

The field of cancer prevention incorporates research all along the spectrum from basic science studies at the laboratory bench to epidemiology, behavioral sciences, and clinical studies, with the convergence of evidence from these different approaches aimed at implementing public health interventions that reduce the burden of this disease. Due to the necessity of multiple disciplines interacting in order to achieve a public health outcome, traditional discipline-specific training may not be adequately preparing the cancer prevention research workforce. We propose that cancer prevention researchers establish defined professional competencies which will allow them to shape the future directions of the field as well as to collaborate effectively in multidisciplinary teams, disseminate new findings beyond their own scientific circles, and advocate for their implementation for the public good. We previously proposed that these core competencies focus on knowledge of issues in other research fields, interdisciplinary communication, and leadership/teamwork. Here we describe the reorganization of an existing course to incorporate activities deliberately designed to foster these competencies. We provide details about the course structure, student feedback, and ideas for future versions of this course. We hope this framework will be useful to others who are engaged in the collective effort to develop leaders in the field of cancer prevention research.

Background

As Baby Boomers age, anticipated growth in the burden of chronic diseases makes expansion of prevention activities a public health imperative. Effective prevention strategies must be founded on a solid evidence base developed from the convergence of research across multiple disciplines. Such is clearly the case with cancer. Indeed, the field of cancer prevention includes countless examples of discipline-specific and cross-disciplinary efforts that involve many different community stakeholders. While individual disciplines of public health, clinical, basic, social and behavioral sciences have made notable advances [1], one

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key area appears to be somewhat slower to evolve: the education and training of researchers in the field.

The traditional model of didactic coursework in undergraduate and graduate school within a single discipline followed by focused application in research apprenticeships has been employed to create junior researchers who are skilled specialists within their own field, but who may have little awareness of advances in related fields and broader prevention goals. Traditionally prepared scientists may struggle within the setting of team science, which has emerged as a predominant model for conducting research today. This new team paradigm has occurred in parallel with the call for research emphasis on multi-factorial dynamic problems in health and society, which require multidisciplinary collaborative team efforts [2–4]. In addition, some researchers struggle to navigate the changing expectations for scientists to participate more vocally in advocating for improved policies and actions that benefit public health because traditional discipline-specific training may result in scientists not being equipped to speak authoritatively or influentially to audiences outside their discipline.

Thus, to meet the urgent public health challenges of our era, education and training of prevention researchers must evolve alongside scientific knowledge. One example of a well-articulated framework for transdisciplinary cancer prevention research training is presented by James *et al.* [5]. This model develops the transdisciplinary perspective through the elements of mentoring team, research topic selection, skilled use of Individual Development Plans, a journal club, and professional development sessions, including Responsible Conduct of Research. Another pre- and post-doctoral research training model for behavioral oncology at Indiana University's Simon Cancer Center is interprofessional as well as transdisciplinary, drawing from the schools of nursing, medicine, and dentistry [6]. Other interdisciplinary training programs were previously developed through the R25 training mechanisms to support trainees in conducting interdisciplinary cancer research. These successful training programs provided opportunities for students to engage in team-based research, but without structured activities or integrated curriculum components to specifically foster skill building for team science. While trainees have reported a perception of enhanced skills in transdisciplinary research, these programs do not include a specific approach to facilitate skill development and rely only on exposure to research in other disciplines [7, 8]. As a further step towards the goal of building a well-equipped cadre of cancer prevention researchers, we propose the establishment of defined professional competencies which will allow junior researchers to move beyond their particular research projects to shape the future directions of the field and to collaborate effectively in multidisciplinary teams, disseminate new findings beyond their own scientific circles, and advocate for their implementation for the public good.

A 2014 editorial in JCE [9] introduced the concept of establishing core competencies for cancer prevention research training, focusing on three major areas: 1. Acquisition of scientific knowledge across many research areas involved in cancer prevention, together with awareness of the multiple barriers to preventing cancer; 2. Skills to communicate across disciplines and across stakeholder groups including policy makers, funding agencies, practitioners, and the public; 3. Leadership and advocacy skills in translating research

findings to public health action. These competencies, while focused on cancer prevention, align well with the core elements of team science or interdisciplinary training programs reviewed in a 2015 National Academies report [10]. The common areas for team science were defined as disciplinary grounding, developing a team work culture, integrating concepts from other disciplines, considering societal benefit, and promoting interdisciplinary communication.

Recently, we sought to foster these competencies by intentionally integrating learning activities into a graduate-level course at the University of Texas Graduate School of Biomedical Sciences, *Topics in Cancer Prevention* (“Topics,” spring semester 2015). Table 1 outlines the activities used to foster the three competencies at the individual, research team, and public policy levels. Our goal was to test the effectiveness and appeal of these activities for upper-level undergraduates, graduate students, and postdoctoral fellows interested in careers in cancer prevention research. In this article we report on how we developed and implemented these activities and on their outcomes. Our purpose is to make the activities available to other instructors, training program directors, administrators, and individual mentors. First we describe the course structure, the rationale for and design of the competency-based learning activities, and the student response to the activities. We also present ideas for refinement and further innovation of the activities and their overall significance with respect to course management, cancer prevention education and the ongoing development of a well-trained and effective cadre of cancer prevention research leaders.

Course Design

In the previous traditional design, our course Topics was formatted as two 1-credit-hour, lecture-based survey courses to cover trends in the many fields involved in cancer prevention research. Students in these courses included postdocs, graduate students, and undergraduates. Each class consisted of a lecture given by a senior investigator in cancer prevention and typically focused on the current ongoing research being conducted by that investigator. Although this format provided a broad overview of fields contributing to cancer prevention research, the continued focus on individual research methodologies did not effectively address cancer prevention competencies (scientific knowledge and awareness of barriers, interdisciplinary communication, and leadership). With the restructuring, we sought to activate these competencies by applying active and team-based strategies to support learning through increased student engagement and integration of information across the diverse fields in cancer prevention. A team of three instructors was formed for course design and implementation that also represented diverse disciplinary backgrounds, including epidemiology, linguistics/communication, and molecular biology/pharmacology. The course structure was modified to expand to 2 credit hours (one 2-hour class weekly). The course was first offered and evaluated, as described here, in January – May 2015. The first hour of class was typically used for a didactic lecture and the 2nd hour of class was devoted to student development of a research project using team-based learning and use of the communication and leadership competencies. Didactic lecture topics were also updated to reflect recent trends in cancer prevention research. Lecture topics and in-class team-learning activities are shown in Table 2.

Didactic lectures

Updated lecture topics included core cancer prevention disciplines plus areas new to this course, such as survivorship, energy balance, and health disparities. Lectures were given by leaders in the respective area of cancer prevention research. In addition, one class session featured a senior investigator with substantial experience in team science and an excellent record in collaborative transdisciplinary research who was asked to share real-world examples of experience with multidisciplinary team science in cancer prevention. This interactive Q&A session provided a candid account of the opportunities and challenges of navigating team science dynamics while helping students identify skills needed to prepare for this type of research environment.

Additional structure and engagement was built into the didactic portion of the course. For example, interaction between students and guest lecturers was encouraged by assigning each student to act as Discussion Leader for one lecture. In another activity, students were asked to reflect on the lecture by recording their main “take-away” and “remaining question” at the end of each lecture. These reflections were kept by the students as an ongoing class journal and turned in to the instructors at the end of the course. The purpose of this reflective metacognitive activity is to assist the student in integrating and cementing what they learned that day. These reflections can also be reviewed by instructors to gauge student uptake of the material, although we did not use them in this way.

As described above, this course has a non-traditional content structure in that it does not focus on one discipline or even one research area, but instead it is centered on bringing multiple disciplines together to advance cancer prevention research with the goal of impacting public health. The course began by reflecting on the scientific, clinical, and political factors that limit public health impact of current cancer prevention science. This was conducted with a multimedia adaptation of Dr. Harvey Fineberg’s published commentary [11] and previous lecture at our institution (“Why is Cancer Prevention a Hard Sell?”) along with a brainstorming discussion guided by the instructor. Students generated ideas regarding the barriers to prevention implementation and possible solutions for an “ideal world” where funding was not a limitation.

Students were also introduced to the experience of interdisciplinary communication using a paired “Interdisciplinary Introduction” activity to highlight the challenges of understanding someone else’s research area and experience. Students were paired based on being in different research areas and given 15 minutes to learn about each other’s educational background and research. This activity used a structured form with prompts addressing such questions as how data is obtained and used, how reliability of scientific claims is established, whether work is conducted in large groups, small groups, or mostly individually, and what ideas ‘outsiders’ hold about their field. After this conversation, student pairs were asked to introduce each other to the class. This brief exercise very effectively highlights the challenges of communicating with someone about a research project in an unfamiliar field.

Following this, students were introduced to the team-based research project. This team project was designed with real-world relevance to integrate knowledge from the didactic

presentations and focus on interdisciplinary communication and leadership/teamwork competencies. This also provided a framework to utilize active learning strategies to support improved learning and student engagement.

Students were assigned to teams selected by the instructors to include members across diverse disciplines and ranks in training (undergraduate, graduate, and postdoctoral students). Students enrolled in this class included graduate students and postdoctoral students in the MD Anderson R25T Cancer Prevention Research Training Program; graduate students and postdoctoral fellows that were not participants in the R25T but were enrolled at the University of Texas Graduate School of Biomedical Sciences or the University of Texas School of Public Health; visiting students participating in a short-term research experience; and undergraduates from other local universities. The goal of the team project was to create a research proposal describing a project that would ultimately have a significant impact on cancer prevention, instead of an incremental advance. This was modeled after the MD Anderson Cancer Center Moon Shots program (www.cancermoonshots.org), which provides focused funding to leverage team science approaches that will “rapidly and dramatically reduce mortality and suffering from cancer.” The Cancer Prevention Moon Shot activity portion of the class was mapped with benchmarks/deliverables that mimic the process of grant writing in reality. The timeline of development included identifying a gap in knowledge, evaluating background knowledge, formulating a hypothesis, and defining specific aims. Teams were required to hand in drafts for each of these steps and received written feedback from the team of three instructors. Each team had two deliverables: writing the Specific Aims page for the team’s Cancer Prevention Moon Shot, and giving a 15-minute team presentation to summarize the proposal, including a slide discussing ethics/Responsible Conduct of Research considerations. All team members were required to participate in the presentation that was conducted in front of a mock “study section” using NIH-based research grant review criteria, with guest faculty judges and classmates as reviewers. Guest faculty judges were invited to participate because of their expertise in the research fields included in student projects. Guest faculty judges represented expertise in decision science, cost-effectiveness research, molecular epidemiology, survivorship, and behavioral science. All faculty judges and students provided scoring using the NIH grant review scoring system and additional comments about the research plan and quality of the presentation. Additional comments were collected in the electronic scoring forms filled out by students, guest faculty judges, and the instructors. Scoring and feedback were provided to students during a debrief session on the following (final) day of class, with best team scores winning a “People’s Choice” or “Faculty Choice” award.

The course concluded with an extended debrief to both allow students to process the experience in its entirety and to inform the instructors as to which elements were more or less successful. Both the teamwork aspect and the presentation of the project to the faculty judges provoked emotional responses from students (such as frustration, anxiety, insecurity, but also curiosity, confidence, and anticipation), and the discussion helped put these emotions into context. Additional classroom observations were discussed separately among the team of three instructors (co-authors here) and are described below.

Assessment Methods

Assessment across competencies

Student progress was collected throughout the term using in-class assessments, which were completed on the first day of class and week 16 (final class). Mid-point assessments were also collected as an opportunity to identify and intervene with any problems in the student team dynamic. Assessments covered knowledge/familiarity about cancer prevention and barriers, interdisciplinary communication (self-rated confidence levels and comfort/concerns), as well as teamwork and leadership measures. Students marked a score of their knowledge in different areas of cancer prevention using a spectrum indicator bar, measured as 0 (a lot) to 100 (not at all). Students were asked questions regarding comfort in explaining their research and answering questions with scientists in different disciplines. Finally, students were asked to indicate their level of interest in pursuing a career in cancer prevention and in pursuing a research career. Measures related to communication, teamwork/leadership, and interest in pursuing a research career were measured with Likert type scales (1–5) which were treated as an interval level variable.

Statistical Analysis

A series of one way-ANOVA with repeated measures was conducted to assess if there were significant changes in students' responses across time among students' training ranks (undergraduate, graduate, and postdoctoral fellows). Two participants had an "other" training rank (visiting medical student and registered nurse), so these participants were excluded for the rank-based analyses. These analyses were conducted using SAS Proc GLM. Before analyses, we checked the assumption of sphericity, which is a test for the equality of variances of the differences among all possible pairs of groups for questions measured at three time points. For measures including all students (regardless of rank), we calculated percentage of students indicating each score.

Assessment Results

Eighteen participants completed at least one assessment. Two students only attended the first class and then dropped the course; these students were excluded from the analysis. However, not every question was completed by all students on each of the assessments. For this reason, the denominators differ slightly between measures, as indicated in the results. Student rank and primary degree program/discipline are shown in Table 3.

Competence: Knowledge/familiarity with cancer prevention research

Knowledge of barriers to preventing cancer through behavioral science approaches increased over time regardless of training rank ($F(1, 9) = 15.76, p = 0.003$). Knowledge of barriers to cancer prevention through epidemiology and biostatistical approaches also increased over time with no effect by training rank ($F(1, 8) = 11.01, p = 0.011$). Knowledge of barriers through community-based cancer prevention approaches showed a statistically significant interaction of training rank by time ($F(2, 9) = 9.61, p = 0.006$): while knowledge of community-based approaches increased over time, these differed across training rank. Reported knowledge at the pre-test was significantly lower for undergraduates compared to

graduate students. No significant differences in knowledge of clinical cancer prevention approaches were observed over time ($F(1, 8) = 2.44, p=0.157$) or by training rank ($F(2, 8) = 3.92, p=0.065$).

Competence: Interdisciplinary communication

Graduate students and postdoctoral fellows reported increasing comfort over time in asking another scientist from a different discipline for further explanation of a term or idea they didn't understand ($F(2, 8) = 5.60, p=0.030$); however, this trend was not present for undergraduates. Students did not report a change in comfort level when explaining their own science to others who know little about that research field ($F(2, 8) = 1.37, p=0.308$).

Competence: Leadership/Teamwork

Four teams of four students each developed Cancer Prevention Moon Shots on the subjects shown below. All teams successfully completed the writing assignments, including a Specific Aims page and the team presentation.

- “Identifying Risk Factors Linked to Cognitive Defects Following Treatment in Pediatric AML Patients” (methods/field of study: genetics, epidemiology)
- “Energy Balance, Gut Microbiome, and the Early Onset of Colorectal Cancer” (methods/field of study: molecular biology, behavioral sciences)
- “The ALL (Acute Lymphoblastic Leukemia) Space Race” (methods/field of study: behavioral sciences)
- “The Impact of Health Care Provider-Directed Behavioral Interventions on Hepatocellular Carcinoma Surveillance” (methods/field of study: physician-directed behavioral science and cost-effectiveness)

Observations from Students and Instructors

At the pre-evaluation, 57% of students reported having previous experience occasionally working in teams and 43% reported frequently working in teams. At the pre-test, 7/15 (47%) students indicated that they liked working in teams, 7/15 were neutral, and 1 (7%) student disliked working in teams. At the post-test, 2/13 (15%) strongly liked, 6/13 (46%) liked, 4/13 (31%) were neutral, and 1/13 (8%) disliked working in teams. There was no significant difference in this measure for pre- and post- time points.

A significant limitation to our study is that the small class size limits our ability to detect statistically significant differences. For this reason, we will present comments/classroom observations from students and faculty (guest judges and class instructors) to supplement the evaluation measures and identify progress, next steps, and lessons learned.

From both the in-class communication between teammates and during the final presentations, students from different disciplines became intensely aware of the need to communicate without jargon. Although students initially voiced some skepticism about their ability to work effectively in a transdisciplinary team, each group fully embraced the project and developed a research project building on the different strengths of their team members.

We also observed that the postdoctoral fellows in the teams naturally assumed leadership/teaching roles to support the team progress. Final evaluations included comments regarding the positive experience of thinking through a research project with other students of varying backgrounds and experience, such as “We worked well together despite our different backgrounds, and each of us had something to contribute. I learned a lot from working with postdocs and graduate students.” As reported on the evaluations, 11/14 (79%) students indicated that they agreed/strongly agreed that all of the members of their team contributed equally on the workload of the project. The remaining 3 students (21%) indicated that they were neutral on this question.

Although it is difficult to quantify, the course instructors observed substantial evolution in both team communication and team dynamics throughout the course. These were most apparent in the final preparations of the specific aims page and presentations. For example, we watched as a molecular biology student explained a transgenic animal model to a psychology student and they were able to work together to plan a specific experiment for their project. This example highlights where students were able to move out of their research area to ask questions and learn more about other fields in this team-based classroom experience. One student said she would provide the following advice to students in the course in the future, “Build on the strengths of individuals but be prepared to stretch out of your comfort zone too.” Interestingly, multiple students made comments similar to “Scientists on your team are people too!”, perhaps reflecting an increased awareness that many scientists feel somewhat uncomfortable when pushed outside of their area of expertise. Instead of being intimidated, students noticed that it was a shared experience of discomfort in being out of their narrow field of expertise.

Faculty judges commented on enjoying the experience of hearing about the type of high-impact research students might conduct when given the freedom to “think big” without concern for manuscripts and grants. Faculty critiques of the research proposals often centered on difficulties with specific methodologies or study design. Overall research project impact, significance, and innovation were scored positively for all projects. By scoring other teams and receiving scores/feedback on their own projects, students were able to become more familiar with the NIH scoring process and receiving peer review.

Discussion

The restructured flagship course provided ample opportunity to increase scientific knowledge and awareness of barriers in cancer prevention; however, minor changes could be made to improve student learning and facilitate activation of cancer prevention competencies. While the new course structure allowed us to develop strategies to activate cancer prevention competencies, the restructuring to only one semester did result in reduced coverage of didactic topics. However, the structure can be easily modified for variation and flexibility in the didactic topics and to address different competencies within the team science framework [10].

Each hour of team activity was an opportunity to practice interdisciplinary communication. Although students were initially uncomfortable trying to bridge such disparate backgrounds,

the final projects and presentations showed that students overcame this anxiety. While the instructors closely observed and interacted with each team throughout the semester, some teams faced challenges in managing the team dynamics, including distributing equal workloads and dependability of teammates coming to class prepared for the team's task that day. (Instructors assured the students that these issues were indeed 'real life' and would be something they would encounter during their careers.) Additional formal instruction on managing team dynamics and handling conflict would be a valuable addition to the course that has lifelong relevance.

The overall goal of the team-based research project was to simulate the "real-life" experience of multidisciplinary team science. In the next iteration of this course, we will break lessons down into smaller subprojects for graduated activities, scaffolding skill-building over several class sessions. During the team activities and throughout the research project, students were reminded and coached about the inherent messiness and discomfort that can occur with interdisciplinary communication and team science. We felt that it was important to give students an opportunity to have this "practice" experience in a classroom setting with instructor support, as a low-risk environment for these struggles that would leave them better prepared for team science and interdisciplinary communication in the "real world." Students reported positive experiences working through disagreements in developing the research proposal, describing it as learning to "disagree agreeably." Nevertheless, smaller projects with different teams or partners would allow students even greater practice for both interdisciplinary communication and team dynamics.

The limited number of students and some incomplete evaluations make it difficult to conduct a robust quantitative analysis. In addition, we suggest collecting qualitative data from students, as quantitative metrics alone don't fully capture the student experience. Our evaluations recorded the experiences of students throughout this course, but it is not known if this classroom experience will have a longer-term impact as students experience transdisciplinary and collaborative research projects in their own careers. Follow-up and reflection at later time points is required to determine how (or if) this course prepared them well for multidisciplinary research experiences in the "real world."

While the call for training transdisciplinary scientists has increased steadily, very few faculty and instructors have been purposefully trained in this way. While it may seem challenging for educators to become familiar with the opportunities and challenges of team science, we suggest that this is an ideal opportunity to engage colleagues who are actively pursuing multidisciplinary research projects to share their experience both with students and educators.

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Table 1

Activity x Competence

	Knowledge & Awareness of Barriers to Cancer Prevention	Interdisciplinary (ID) Communication	Leadership/Teamwork
Individual activities	<ul style="list-style-type: none"> • Lead Q & A session after lectures • Personal reflections after each lecture 	<ul style="list-style-type: none"> • ID introductions (explain self; then explain partner to class) • (Advocacy & Inquiry techniques handouts) 	<ul style="list-style-type: none"> • Self-awareness questions pre-, mid-, post-
Research team activities	<ul style="list-style-type: none"> • Contribute own disciplinary perspectives; learn those of others; integrate into a unified solution 	<ul style="list-style-type: none"> • Collaborate on group project 	<ul style="list-style-type: none"> • Consider teamwork challenges • Clarify roles • Make decisions • Manage conflict
Public/advocacy activities	<ul style="list-style-type: none"> • Identify high-impact problems 	<ul style="list-style-type: none"> • Prepare presentation for diverse audiences • Respond gracefully to unexpected challenges and audience reactions 	<ul style="list-style-type: none"> • Promote and defend project in a competitive format • Explain public health impact

Table 2

Lecture topics and team-learning activities

Lecture topics (first hour of class) (Supporting the competency of scientific knowledge and awareness of barriers)	Team activities (second hour of class) (Supporting competencies of interdisciplinary communication and leadership, plus scientific knowledge)
Course introduction, barriers to cancer prevention	Why is Cancer Prevention a Hard Sell? Video featuring Harvey Fineberg, followed by discussion
Health Disparities in Cancer	Interdisciplinary communication skills, introduction to team projects
Cancer Epidemiology	Extended example of existing interdisciplinary cancer "Moon Shot" team science example, development of aims for team project
Genomics and Cancer Prevention	Teams begin project development
Energy Balance & Team Research	Complete gap in knowledge and introduction on Specific Aims page
Chemoprevention	Dissection of aims examples, writing Specific Aims
Behavioral Theory and Interventions	Project development
Implementing Cancer Prevention Services in Community Health Centers	Finalize drafts of Specific Aims by end of class
Principles of Cancer Prevention	Instructors provide feedback on aims
Tobacco Addiction and Treatment Research	Team presentation planning and organization
Clinical Trials in Cancer Prevention	Final Specific Aims due
Project work day and "gallery walk" to view draft presentation slides from each group	
Survivorship	Presentation rehearsals
Final presentations and study section review/scoring	

Table 3

Student rank and primary discipline

Rank	N (%)	Primary discipline
Undergraduate	3 (19%)	chemistry, molecular biology, health disparities, psychology
Graduate Student	6 (38%)	behavioral sciences, epidemiology (3), health disparities, epidemiology
Postdoctoral Fellow	5 (31%)	molecular biology, behavioral sciences, epidemiology, public health, health services research
Other	2 (13%)	visiting medical student, registered nurse