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Ideas and Approaches for Teaching Undergraduate Research Methods in the Health Sciences

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Training in research methodology is becoming more commonly expected within undergraduate curricula designed to prepare students for entry into graduate allied health programs. Little information is currently available about pedagogical strategies to promote undergraduate students' learning of research methods, and less yet is available discussing the challenges and benefits of such approaches for students and faculty. The present article provides a brief review of literature of pedagogically descriptive articles, provides two further examples of possible approaches, and discusses the challenges and benefits of using the described approaches to teach research methods to undergraduates in the health sciences.

The inclusion of research methods in pre-professional health education has been a topic of discussion since the 1970s (Johnson, 1973), but though effort has been directed at achieving this aim, little is written about successful pedagogical approaches. Undergraduate research experiences are categorized as high impact learning practices (National Survey of Student Engagement [NSSE], 2013) which may come through competitive, structured institutional enrichment opportunities (often in summer), honors programs, or faculty mentoring (e.g. independent studies or participation with faculty research projects) (Blanton, 2008). After being involved in such experiences, students report gains on numerous knowledge and skills including the ability to understand the research process/design, conduct research, analyze and interpret data, and understand primary literature (Lopatto, 2004; Seymour, Hunter, Laursen, & DeAntoni, 2004). The development of these skills may be dependent upon the stage of involvement in the research project (Adedokun et al., 2014). Undergraduate research experiences may expand awareness of opportunities after the undergraduate degree; reinforce, clarify, or change career and graduate school aspirations; and increase their professional qualifications (Adedokun, et al., 2012; Russell, Hancock, & McCullough, 2007; Villarejo, Barlow, Kogan, Veazey, & Sweeney, 2008; Willis, Krueger, & Kendrick, 2013).

There is increasing emphasis on research within the allied health fields of physical therapy, occupational therapy, and physician assistants. The allied health fields (and nursing) support evidence-based practices which require erasing or crossing the line between research and practice. The research agenda of the American Physical Therapy Association includes 80 items within seven categories of research: basic science, clinical, education/professional development, epidemiology, health services research/policy, workforce, and measurement development and validation (Goldstein et al., 2011). The research agenda of the American Occupational Therapy Association and the American Occupational Therapy Foundation (2011) includes 23 major research goals within five categories: assessment/measurement, intervention, translational, basic, health services, and research training. The prioritized research agenda from American Academy of Physician Assistants includes 20 research topics within four areas: value, roles, workforce, and education (Fang, 2012).

Thus, it may be important to provide a foundation and instill excitement for research among pre-professional health undergraduate students. Familiarity with research skills would inform knowledge translation or the application of knowledge to healthcare decision making (Strauss, Tetroe, & Graham, 2011): the central element to evidence based practice. However, according to the National Survey of Student Engagement (2013), a lower percentage of senior undergraduate students in the health professions (18%) report participating in research with faculty compared to all senior undergraduates (23%). The difference is greater when comparing these health profession students to those in biological (45%) and physical (39%) sciences. Teaching and learning strategies and activities within a course in research methods may provide the opportunity to engage more students in undergraduate research and achieve similar benefits for students who participate in extra-curricular research.

Only a few pedagogical techniques of undergraduate students are described in the literature, many of which come from the field of nursing. Table 1 summarizes the characteristics of the undergraduates, selected activities of the course, information related to the use of Institutional Review Boards, and any reported outcomes. The number of students involved in the courses varied considerably. The use of literature reviews, article critiques, and research proposals occurred frequently. When original data collection was included, the research project was initiated or directed

Table 1
Selected Characteristics of Pedagogy for Undergraduate Research Methods

	Population	Assignments / Activities	IRB	Outcomes
August-Brady, 2005	N = 9 Undergraduate nursing Moravian College	Survey modification Survey development Data collection Article critiques Formal mini-integrative literature review Data analysis Oral and Poster Presentations	No IRB indicated External	Qualitative
Dobratz, 2003	N = 47 (total) 2 classes Undergraduate nursing Mount St. Mary's College	Class discussion Abstract cards Research report critique Research proposal (poster)	No IRB	Course evaluation
Henderson, Buising, & Wall, 2008	N ≈25 per semester Biochemistry Drake University	Multi-year process for novice researchers, primary researchers, and student mentors 2 hrs/wk discussion 12 hrs/wk laboratory Assignments vary by student level: Research participation Research pre-proposal Research abstract Literature review Mentoring Research Report	No IRB (not human research) External	Project productivity presentations
Hitchcock & Murphy, 1999	N= 56/61 (usable) Undergraduate nursing College of Our Lady of the Elms	1st semester Junior year : Students were subjects in faculty research project 2nd semester Junior year: In the required research course, students became data collectors in an expansion of original faculty research project including interviewing lay persons The faculty research project was used to discuss / relate course content Faculty entered and analyzed the data then reported the findings to the students at the end of the semester in a research forum	Informed consent of lay persons No student IRB project	Three-page reflection paper on data collection experience Positive attitudes toward research
McCurry & Martins, 2010	N = 72 Undergraduate nursing University of Massachusetts Dartmouth	Small group worksheets. Clinical nurse researcher presentations and discussion Literature review-summary Student group presentations of published research Small group article discussions *"The Great Cookie Experiment"*	Exempt for course evaluation	Student reported effectiveness for achieving objectives comparison to traditional assignments
Pfeffer & Rogalin, 2012	N= 10 Sociology Purdue University North Central	Active learning assignments: literature review and research proposal, qualitative coding activity, IRB training 4 weeks of guest (Intradepartmental) discussion series: students read authored research and developed discussion questions Real world context: (same) guests discussed challenges, rewards, motivations of researchers	No research project completed	Positive (quantitative and qualitative) course evaluations

by the instructor. The instructors may be responsible for decisions within the research project such as instrument selection and sampling (Hitchcock & Murphy, 1999) or for providing the data to be analyzed (Pfeffer & Rogalin, 2012). While some of the research courses required students to complete ethical research trainings, none of the courses included student-initiated projects which were subject to Institutional Review Board approval.

Learning Model: Team-Based Learning

Educational aims for health science undergraduates have moved from simply transferring content and knowledge to the emphasis on critical thinking, application, and creative problem solving (Bagnasco et al., 2014). Team-Based Learning (TBL) has gained popularity as an evidence-based teaching approach in recent years (Michaelsen & Sweet, 2011; Parmelee & Al-Kadi, 2014). TBL differs from traditional didactic experiences in education by creating an engaged learning process emphasizing application rather than simple rote memorization (Bleske et al., 2014; Hrynchak & Batty, 2012). Based in constructivist theory, TBL is an active learning approach that turns the focus of learning to the student and utilizes problem solving and cooperative learning (Hrynchak & Batty, 2012). TBL has been supported as an active teaching and learning approach that may facilitate meaningful learning (Gleason et al., 2011) in all of the domains of Bloom's taxonomy (Allen et al., 2013), including the higher order thinking processes undergraduate faculty often desire to develop most.

Parmelee (2011) established two distinct uses of small group learning within the education of health professionals: discovery (suited for complex ethical considerations) and accountability (where content mastery leading to application is the primary concern, often seen with TBL approaches). Studies supporting the use of TBL in the preparation of health professionals abound (Koles, Stolfi, Borges, Nelson, & Parmelee, 2010). TBL has further been used to prepare students for changes in educational experiences by shifting them towards problem-based issues they will face in future training and in their careers (Abdelkhalek, Hussein, Gibbs, & Hamdy, 2010).

The effectiveness of TBL isn't without contrasting findings (Sisk, 2011). Willet, Rosevear, and Kim (2011) compared team based learning versus small group learning with a sample of second year medical students and found students preferred small group learning though both groups performed similarly on exams. In the undergraduate environment student satisfaction is a factor important to the evaluation of faculty, and therefore this finding should be considered. Accordingly, Davidson (2011) suggests developing TBL as a classroom approach is an iterative, slow, and deliberate process for the instructor.

Undergraduate students in the health sciences are an underserved population in attaining research experience. These students may benefit from participation in research experiences not only as undergraduates, but also as they apply to graduate programs and as health professionals. Limited pedagogical techniques are available to use as models for increasing undergraduate research with larger numbers of students and limited resources. TBL within the context of student-initiated, IRB-approved research projects may be used to achieve similar outcomes as more resource intensive strategies. The purpose of the paper is to provide a comparison of pedagogical techniques using TBL to facilitate learning outcomes of an undergraduate course in research methods.

Context Description

Both authors maintain tenure-track assistant professor positions in a teaching intensive department with a 4/4 undergraduate teaching load within a large selective four-year, primarily residential public university with the Carnegie designation of balanced arts and sciences/professions with some graduate coexistence. The research methods course is required for seniors pursuing a BS in Health Sciences. The course is offered in both academic semesters, and classes either meet three days a week for 50 minutes each or twice a week for 75 minutes. Typically, there are seven sections of the course per semester with 20 to 30 students per section. The authors present two approaches to teaching research methods through the use of a student-initiated, IRB approved research project.

Approach 1

After a brief introduction to research methods and criteria used in consideration of problem selection, students are asked to submit three research topics they would like to work on throughout the semester. After reviewing these topics, the instructor lists four to six topics that occur frequently and/or include exceptional novelty while excluding topics that exceed the available resources. Students are assigned a number, and then a random number table is used to determine the order in which students are able to choose a topic and group; groups include four to six students each.

After group introductions and discussion to refine the initial research topic, students begin the first individual assignment: a multi-step process culminating

in an annotated bibliography. While each step is completed as an individual, students discuss their outcomes with group members and refine the research question before proceeding to the next step. Students locate, read, and evaluate a published literature review to identify gaps in the literature, justify delimitations of their project, and identify possible procedures and instruments. Students identify a theoretical perspective which will guide the development of hypotheses and define the constructs within the context of the project. After identifying key words, students conduct a literature search for peer-reviewed journal articles. From the search, students choose six articles to read and create annotations with specific implications for the proposed research project. The annotated bibliography assignment concludes with a synthesis across the annotations and the revised research question.

After written feedback is provided for each submission, each student locates two published surveys to operationalize variables within their project. Through the development of a preliminary methods section for the research proposal, students describe the items on the instruments, the scoring procedures, the data collection procedure, the sampling, and the data analysis plan related to the hypotheses. Students incorporate additional sources to evaluate the validity and reliability of the instruments. Each student's investment in these instruments facilitates the discussion and debate over instrument selection within the group.

The first group assignment is a written research proposal including an introduction, literature review, and proposed research procedures. Because of the required preliminary individual work, each group typically has 25-30 sources to justify the research proposal and numerous instruments from which to choose in the proposed data collection procedures. After written feedback is provided for the extensive research proposal, a revised abbreviated version is submitted to the university's Institutional Review Board. The submission includes the finalized data collection instrument and informed consent document. The instructor accepts the role of research advisor and allows the students to retain the role of Responsible Researchers. Review requests submitted by the students may qualify for either an exempt or expedited review. The students work with the IRB to resolve any concerns until the research is approved. To be compliant, students complete an external certificate program for social and behavioral research with human subjects.

While the IRB is reviewing the requests, each group develops a codebook within SPSS which is then distributed to all group members. Upon IRB approval, each student collects data from at least 25 subjects and enters the data into SPSS. Typically, data collection includes the distribution of printed surveys and collection through a secure dropbox to maintain anonymity of participants. The individual datasets are combined, and then the students develop the syntax following the established scoring protocol of the surveys. Using the data analysis plan established in the research proposal, the students test and interpret their hypotheses. At this point in the semester, students have a better grasp of appropriate statistical procedures and may elect to revise, improve, and augment the original data analysis plan.

The final research report is developed by revising the original research proposal, incorporating the findings from the data analysis, and comparing their findings to the existing literature. Within the final exam period, each group presents its study within the context of a professional conference to model professional practice.

Assignments within the research project (both individual and group) contribute to approximately one third of the final grade in the class. Students complete peer evaluations of all group members, including themselves, three times during the semester: after the literature review submission, after the IRB submission, and after the final paper and presentation.

Approach 2

Initially, this approach began by following the traditional first five chapter model in order (introduction, literature review, methods). However, over recent semesters this approach has been modified substantially based on several internal and external factors to present the methodology significantly earlier in the process. At present the project is aimed at developing a final paper in manuscript form and a poster presentation.

The project works at balancing content exposure, application of course content within the project, and group driven inquiry. A small pre-test with a writing sample, their stated career goals, and self-reported academic performance are used as a method of placing students with similar interests and habits into groups. At the beginning of the semester, team and whole class discourse surrounding team topic selection is used as an important piece in establishing a community of active, engaged learners within each class. Open discussion also allows students to be inspired by teams who have chosen to pursue more challenging or innovative topics. Topics must be approved by the instructor typically by the end of the second or third week.

Once a topic has been approved, teams begin reading and accumulating information into a matrix. Using a file-sharing application such as Google Docs or Dropbox, students create a matrix similar to an annotated bibliography, but in table form where each row represents a different article. The matrix includes the following columns: proper APA citation, topics

(dependent and independent variables) covered in the article, study design / methods, population and sample size, instruments used, a brief summary of findings, and a column for comments where students can place any information they want to keep track of for later. Each student identifies his / her contributions by typing initials of the student recording each article (this also helps the instructor check that all group members are participating). The completed matrix includes twenty or more articles that facilitate the development of three to five research questions within each team based on their newly gained knowledge. Following each and every team submission a peer and self-review of contribution is submitted by each student electronically via Qualtrics; students are required to identify tasks each person within the group completed as well as their own contributions. This evaluation approach provides the much needed accountability often lacking in team environments. Each student completes an external certificate program for social and behavioral research with human subjects early in the term and outside of class, so they are familiar with ethical principles of research conducted with humans.

The focus of the course moves rapidly to methodology. Design, sampling, quantitative versus qualitative approaches, instrumentation / scoring, and writing an analysis plan are often foreign concepts to undergraduates. Spending time on these elements first enables the student to consider the literature they are reading in a new way and to develop ideas about how studies are designed in relation to their topic, as well as to learn the benefits and limitations of those approaches. The aforementioned approach is an internal reason to move rapidly into methodology; however, the external reasoning is attempting to develop the methodology in order to meet IRB submission deadlines with enough time remaining in the semester to collect data and complete the project.

Students submit the methodology section (design, sampling, instrumentation, and analysis plan) to the instructor. During the following class period, each team reviews the projects that are not their own and provides written feedback to the other students. The instructor provides instruction on giving and receiving constructive feedback. The instructor is committed to reading and providing written feedback by the end of the day. This peer review process allows students to receive multiple critiques of their submission. Students are also able to compare and learn from the submissions that they evaluate. The quick turn-around is a time challenge for the instructor; however, identifying significant methodological flaws early prevents a lot of wasted time for everyone and also helps the IRB submission process go more smoothly. Students have one week to make improvements and re-submit the document to the instructor for a grade. The week following their re-submission, the students complete the IRB paperwork using both in class and out of class time.

After completing/submitting the IRB document students turn their attention to writing a more thorough representation of the literature. One class period is typically dedicated to a writing center workshop regarding sentence level revision. The literature review phase is the most familiar piece of the paper to students.

Typically, students receive IRB approval for their projects within a matter of a few weeks as projects are limited to expedited or exempt IRB categories. As data collection begins the lectures shift to descriptive and inferential analysis followed by the essentials of entering data and SPSS (recoding and calculations). Data collection procedures are dependent upon the methods section but may include observation, physical measurements, and/or written surveys. The classroom moves to a computer lab for the latter components, allowing teams to use their own data to complete the steps described. Students continue to use their new skills independently to complete data entry and recoding while lectures focus on data communication (how to use graphs, charts and tables) and assistance in developing the layout of the results and conclusions sections of the paper. Students submit a completed project (manuscript form) the week before finals and orally present their team poster during finals.

Challenges, Limitations, and Points of Discussion

The two approaches discussed above may have several benefits for health science programs as compared to other techniques. Using the TBL approach, approximately 180-200 students per year are able to participate as primary investigators in IRB approved research projects completed inside singular semesters. Other approaches either require multiple semesters (Henderson, Buising, & Wall, 2008; Hitchcock & Murphy, 1999), have only been used with significantly smaller classes (August-Brady, 2005; Pfeffer & Rogalin, 2012), or require only a research proposal (Dobratz, 2003; McCurry & Martins, 2010). The two approaches outlined here use forms of TBL and small group work to complete a research study within one semester. The two approaches use slightly differing strategies to arrive at a similar outcome: the completion of the study. The benefits of undergraduates completing research projects as described in this paper fall in line with the benefits of TBL described in the review of the literature: the process is active and forces student engagement; the process focuses on application, not just memorization, of knowledge on multiple levels (understanding the task they need to complete *and* understanding the literature related to the chosen topic); it utilizes the upper levels of Bloom's taxonomy

(application, analysis, synthesis, and evaluation); and it requires students to work collaboratively to problem solve and think critically. Together these learning experiences may lead to deeper, more meaningful learning for students.

A direct comparison of student learning outcomes between the two approaches is difficult because the courses differ in other ways, the two instructors are not the only instructors of this course, and there are multiple course scheduling factors which influence course section enrollments. Across several years the authors have utilized different outcome objectives for the class (test/memorization based, first 3 chapters/proposal only, and full project), each time modifying the course to improve areas where learning was weakest. The approaches described here are those that have yielded better learning as demonstrated by increased quality of final projects and improved ability to intelligently discuss findings during final presentations (describing their own study, responding to peer questions, and asking insightful questions of each other). After completing the course students report that the research process is demystified and therefore less intimidating, that they feel more competent when reading the literature, and that they have a sense of pride in having completed such a big undertaking. Further, as students matriculate and begin graduate programs, their feedback to the faculty members expresses a sense that the skills gained have made them feel well prepared and helped them succeed.

However, TBL to complete a student-initiated, IRB approved research project in one semester is not without its own challenges. A few of the most common challenges faced by faculty and their students are listed in Table 2; similarities and differences between the two approaches are discussed below. Undergraduates may not complete tasks or meet expectations without further training and input from faculty beyond class time and traditional office hours; therefore, the time cost-to-productivity benefit ratio is a concern for faculty mentors. The time cost of training might be lessened in laboratory settings in preparatory courses where students can be trained once for a discreet, repetitive skill set. The application can be more challenging in community engagement or live persons work where the environment and reactions need to be more dynamic.

While both approaches use TBL to conduct a student-initiated research project in one semester, the differences need further discussion. The timelines and order of course content differ. Approach 1 focuses almost completely upon survey research and uses separate learning activities to address experimental research. Approach 2 presents all methodologies first, allowing greater variety of choice for research projects among students. The difference in timelines between the two instructors is a potential benefit to other campus resources. The librarians and the Writing Center are able to manage the requests for contributions of their time and guidance for students who are at different points of the process at slightly differing times. This benefit may be most apparent for the Office of Research Integrity, which provides initial screening and organizational oversight for the Institutional Review Board. Teams guided by approach 2 often submit their project for IRB approval ten to fourteen days sooner than groups under approach 1. Having 16-20 projects submitted simultaneously may be more burdensome than the same number of projects submitted over two weeks. Thus far, all student groups have been successful in obtaining IRB approval. Both approaches reinforce the cyclical nature of the research process.

The process of determining which students are in which groups also differs between the two approaches. In approach 1, all students within a group express an interest in a particular topic. Through the random order, individuals at the end of choosing topics have fewer choices, but they are able to see who is already in a particular group. As researcher interest is a key consideration in the selection of a research problem (Neutens & Rubinson, 2014), this approach is meant to discourage apathy. However, students selecting their own groupings may result in students with differing motivations/abilities/pre-requisite skills ending up in the same group. Students have differing ideas of the topic to which they signed up. In approach 2, there may be less difference in motivations/abilities/pre-requisite skills within each research team. However, there is a greater negotiation of the research topic which has the potential to be dominated by one group member.

Students are often unable to come up with researchable problems at the beginning of the course. They are often either unclear about what research is (distinguishing it from a research paper or lab they may have written in an introductory course) or unrealistic about what can be achieved in a semester (curing cancer). Regardless of approach 1 or approach 2, the faculty member is tasked with guiding students to a sufficiently narrow topic and identifying realistic variables that have existing measures. The faculty member need not be an expert in multiple content areas, but he or she must possess the research skills to assist refinement of research questions and identification of instruments. TBL is used to overcome this challenge. It is the responsibility of the teams to justify their choices with evidence and to convince the faculty member of their rationale. When the students are expected to be the content experts, the questions addressed to the faculty become more meaningful. They change from, “What is the answer?,” to, “How do I find the answer?,” and they change from, “What should I do?,” to “This is what I want to do, so how do I do it?” Just as faculty time is a limited resource, student time and time management are challenges. The course

Table 2
Identified Challenges for Students and Faculty in Relation to Teaching Applied Research Methods

Challenge	Student	Faculty-Program
Balance of teamwork and individual responsibility	Portion of grade dependent upon fellow student ability and engagement	Equitable assessment
Perceived differences in rigor across sections	Student satisfaction may be impacted by perception of learning more or "easier" class	May impact student evaluation of course / instructor used in promotion-tenure decisions
Completing a project inside a single semester	Extensive out of class time commitment	Covering course material not directly applicable to research project (evaluation research)
Research problem selection	Engaging this process can be overwhelming at the start	New topics every semester; Multiple content expertise
Ethical challenges	Student appreciation for human rights?	Study participants volunteering for potentially un-publishable work
Effort/time burden vs. benefit	Perceptions may vary in relation to perceived utility in future career field	Delays in student appreciation of benefit; Labor intensive approach for faculty may have additional productivity costs; Is this teaching, service, or scholarship?
Class Size	Unique small class environment	More sections must be offered in order to keep class size small.

is currently only three credits (unlike lab sciences which garner 4 credits), and most students are enrolled for 15 -18 credits total. The course represents 16-20% of their course load. Students may perceive the level of involvement and time commitment required by the project in this course as outweighing potential benefits. The requirement for individual and group assignments (approach 1) may overly burden the students. Approach 1 relies more heavily on individual assignments to "accurately" assign grades. The individual assignments may provide greater evidence of contributions to group assignments. The underlying assumption to this strategy is that the higher quality individual submissions are more likely to be incorporated into the group project. Peer evaluations are used to rectify substantial differences in quality or quantity of contributions of group members to group assignments. Within some groups, all individual assignments contain similar content errors or lack of depth. Approach 2 relies more heavily on assigning grades for group submissions and adjusting the grades of individuals based upon the peer evaluations and assessing individual knowledge or ability to apply knowledge via examinations. Prospectively recording task distribution, establishing and monitoring internal team deadlines, and journaling student activities may provide more complete characterization and evidence of individual contributions to the team submissions.

For students who excel in the class, the course creates a strong foundation for a recommendation for graduate programs including: physical therapy, occupational therapy, public health, and physician assistant. For faculty, the projects can identify students for independent studies or for research assistantships. Utilization of TBL to complete a student-initiated, IRB approved research project within the confines of a one semester course in the health sciences is challenging and rewarding for both faculty and students. Faculty and students in other disciplines may be able to use a similar approach. Further research is warranted to investigate student outcomes relative to different types of instruction in research methodology and the subsequent performance in graduate programs.

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