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Nuclear Medicine Technology Undergraduate Research Methods

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1. Indiana University School of Medicine

Abstract

Introduction: The purpose of this article is to introduce nuclear medicine technology (NMT) educators to a method of incorporating research methodologies into the curriculum. **Methods:** The research methodology in the NMT program at Indiana University (IU) is taught in five steps (1. Introduction to research articles and statistics 2. Mock project and individual project design 3. Data collection 4. Writing the research paper 5. Presenting the abstract and mentoring new students). These steps could be combined for programs of shorter length or with credit hour restrictions. **Results:** In the past four years, all IU NMT students (100%) presented their research abstracts as part of a continuing education program for technologists. Seventeen of twenty-five (68%) presented their abstracts at a regional professional meeting. Six of twenty-five (24%) presented their research abstracts at a national professional meeting. Three of those six (50%) received travel grants. Two students submitted their research for publication and one was successful. **Conclusion:** The goal of incorporating a research methodology program into the nuclear medicine program should be to introduce undergraduates to the research process and instill excitement for new technologists to continue participation in research throughout their career.

Keywords: undergraduate, research, methodology

Introduction

Undergraduate students benefit from research experiences (*1*). Research methodology has become an important part of the nuclear medicine technology (NMT) curriculum (*2*). There are many ways to incorporate research methods into an NMT program. This article is based on the research program I implemented at Indiana University (IU) in the NMT program. My program is a 2+2 program, meaning that students participate in 2 years of pre-requisite work prior to entering the NMT program. Students begin the program in the summer session before their junior year and complete a full five semesters in the professional program.

The purpose of this research program is to introduce students to the importance of performing research, research methodologies and becoming a critical reader of journal articles. This introduction into research provides them the groundwork they need as they move through their careers as nuclear medicine technologists. It is important to emphasize that producing results that will change the practice of nuclear medicine technology is not the purpose of this program. The outcomes and learning objectives I use are listed in table 1. They are adapted from the SNMMI Nuclear Medicine Technology Competency Based Curriculum Guide 5th edition (*2*).

I cover this research program in five steps. Each step represents a one credit hour course. Several of these steps could easily be combined or abbreviated to accommodate shorter programs or those with credit hour restrictions.

Methods

Step One: Introduction to research articles and statistics

I believe that the first step is to introduce students to the library. Many colleges and universities allow students to access the library on-line. This is convenient for students and they should (and will) take advantage of it. However, I find that students don't understand that there

is a difference between what you randomly find online (usually via a google search) and what is available to you when you are performing a literature search through your school's library (*3*). The best way to do this is to take them to the library. I arrange with our librarian to give a presentation on library services and how to use them.

As part of the library orientation, my students are introduced to using citation software. The days of me counting the spaces, commas and periods are over. Endnote is a popular citation software utilized to manage information (*4*). I require my students to download the software on their personal electronic devices and use it throughout the program. The Journal of Nuclear Medicine Technology (JNMT) has its own style for endnote that can be downloaded from the endnote site. I do this in the beginning of the program to prepare students if they wish to pursue publication, either as a student or later as a technologist.

During this first semester, I introduce students to the differences between a research article and a literature review article. I assign two articles (a research article and a literature review article) for students to read. My students are given a series of questions that encourage them to compare and contrast these two types of articles. I keep in mind that this is the beginning of the program and students will not understand much of the content of the assigned articles. Therefore, I assign articles that are short, are relatively easy to read and contain subject matter they will see early on in the clinical environment. An example of two such articles are listed below:

Research Article: "The Necessity of Using Heparin in an UltraTag RBC Kit when Tagging Blood for a Nuclear Medicine Study" by Pigmon, Weatherman, Brehl and Nielsen (*5*)

Review Article: "Myocardial Perfusion Imaging with Tl-201" by Pagnanelli and Basso (*6*)

Once students understand the difference between a research article and a review article, the next step is for them to learn the sections of a research article and how to critically read a

research article (*7*). I assign a series of questions breaking down a research article and identifying any limitations that may not be listed within the article. I believe the only way to become a critical reader of journal articles is through practice. I assign journal articles throughout the program to build this skill.

The final step when introducing students to research is preparing them for projects with human subjects. I have all students complete a module on human subjects research. The students at IU use the Collaborative Institutional Training Initiative (CITI ™) which offers an on-line course they can take to prepare them for doing research with human subjects.

Finally, students will also need a basic understanding of statistics. They need this to understand reading journal articles, as well as performing their own research projects. I try not to teach too much depth in this subject. I believe an appropriate level is to give a brief overview on descriptive vs inferential statistics, T-tests (one sample, two sample—paired and unpaired), ANOVA and linear regression (*8*). While this sounds like a lot, it really isn't. I find that it is only necessary to cover for what situation each statistical method is appropriate, how to use each statistical method and how to interpret the results. There is free software (i.e. analysis tookpak from excel) that can do all of the calculations. If a student chooses a project that requires higher order statistics, I recommend they seek outside help. Our university provides a walk-in statistics clinic once a week for this very purpose.

Summary:

1. Introduction to the library and citation software
2. Compare and contrast a research article and a review article
3. Learn the parts of a research article and how to critically read a research article
4. Introduction to human research subjects—CITI training
5. Introduction to statistics

Step Two: Mock group project and individual project design

Mock group project:

The second step in my research program is to walk students through a mock group project. I divide students into two groups and provide them each with a research claim. I guide them through the steps of creating the design of this project based on their given research claim. While they are working through this mock group research project, I encourage students to start thinking about their own research ideas. I do this by having them brainstorm in class regarding their own project ideas while working on this guided project.

The research claims I provide are simplistic in nature. The purpose of this exercise is to introduce students to the steps of performing research. It is always interesting that given the same research claim, my students will find different ways to design their data collection and measurements. Here are two research claims I have used in the past:

- Syringe shield A blocks 90% of the photons from a Tc-99m source
- Syringe shield A blocks more photons from a Tc-99m source than syringe shield B

Based on the research claim, I have students prepare an annotated bibliography. They must each find an article that relates to the research claim that answers the question, “Why is it important to measure this research claim?” Students tend to have trouble with this assignment. They want to be very specific and find an article that directly *explains* what they are researching instead of *supporting* what they are researching. My students are required to write two paragraphs for each article they find. The first paragraph summarizes the article and the second paragraph explains how the information found in the article supports the research they are doing.

I have found that students have a tendency to want to immediately jump into research design, mainly the methodology and materials needed. At this point, I require my students to

take a step back and define the research question, state the null and alternate hypotheses and guess what they think the results might be.

I encourage students to think about multiple ways to design their research methodology. For example, in the given project of evaluating syringe shields, they may use varying activities or varying volumes. They may use different distances as well. They also need to decide the equipment they will use (GM meter, dose calibrator, portable ionization chamber, scintillation detector).

My students must also create a data collection sheet. I have my students look at the statistical methodology when constructing their data collection sheet. Many times, the research methodology will change when students construct the data collection sheet. I have my students insert mock data and run their statistical method to see if it “makes sense”. This is a good way for students to check their work. I teach my students that they should always have their research design complete prior to collecting their data to limit any bias. I have found that the best way to do that is to have them complete the project with mock data prior to collecting any real data.

I give my students the opportunity to collect their own data for this group mock project according to their research design. I have a dedicated lab for them to use. However, if a lab is unavailable, using the hot lab of a clinical site may be an option. I supervise my students, but allow them to make mistakes during this data collection exercise.

The final step of this guided group project is for my students to write an extended abstract (or a brief paper). I have them write this using everything they learned about research articles. I also require that they use the JNMT format in EndNote. Educators should not get discouraged if the final product is less than ideal. Remember, this is their first try doing something like this. I

use this as an opportunity for them to practice writing before they do their actual research project. I also have students present their abstracts to their classmates.

Individual Project Design:

While students are working through the mock group project, I have them brainstorm their individual project ideas. For example, when they are working on their mock research question and hypotheses, I ask them to share with the class what their individual projects will be. For their individual projects, they will need to make a claim and construct a research question. Sometimes their project idea starts as a claim or an observation (i.e. You do not need to use heparin when tagging red blood cells). And sometimes, the project idea starts as a question (i.e. Do you think eGFR affects SUV values?).

I require my students to identify a research supervisor to help guide them through their project. The research supervisor should be someone with knowledge about what the student is researching to fill any knowledge gaps. For example, if the student is doing a project involving infection control, I encourage them to seek out a nurse to be their supervisor. If a student is doing a project involving radiation protection, I encourage them to seek out a physicist to be their supervisor. I advise students to avoid choosing a recent graduate from the NMT program. New graduates tend to be extremely busy starting their careers and current NMT students will be left without an actively involved supervisor. I have students and research supervisors sign an agreement so each party knows their responsibility in the project. See Figure 1: Research Supervisor Agreement. My students are ultimately responsible for all aspects of the project. The supervisor is only responsible for guiding the student, holding them accountable for their progress and answering questions.

The next step is to perform an annotated bibliography to support their research claim. I have students find four peer reviewed journal articles and compile them the same format as the group mock project.

My students are finally ready to define the materials and methods for their projects. The students must consider several factors. Is there a financial cost? Does this include human subjects and require IRB approval? Can data be collected in the period allowed? Many times my students will change their project idea several times during this exercise. I also invite a nuclear medicine physician who assists students in designing their projects. The nuclear medicine physician listens to their ideas and provides feedback on how to make their project better. I require my students to have their research claim prior to meeting with our nuclear medicine physician.

At the end of this course, I require students to prepare their data collection sheet and determine the statistical method they will employ. If they require IRB approval, I encourage them to start this process as early as possible.

Summary:

1. Group project
    a. Claim given to students and they define research question and hypotheses
    b. Brief literature review to support the purpose of their research
    c. Construction of materials and methods
    d. Data collection sheet, statistical analysis and mock data
    e. Data collection
    f. Extended abstract (or brief paper) and presentation
2. Individual project
    a. Research claim and question

b. Literature review
c. Null/alternate hypotheses
d. Find a research supervisor
e. Materials and methods
f. Statistical tool and mock data analysis
g. IRB application and approval (if needed)

Step three: Data collection

This third course is mainly independent study. During this full-semester course, the students are responsible for collecting and analyzing their data and presenting their results to their classmates by the end of the term. Prior to being cleared to collect their data, students must meet with me to identify and discuss their research question, null and alternate hypotheses, and research design (materials and methods, statistical analysis techniques, etc.). They must submit at that time a signed verification form from their research supervisor confirming his or her involvement in the process. If a student is not cleared to begin collecting their data during this initial meeting (due to problems with their design, lack of materials, etc.), I allow them one additional meeting without consequence. If they are not cleared during this second meeting, they incur a grade deduction. This is true for any subsequent meeting that may follow until they are officially cleared to collect their data. I believe this incentive encourages students to plan early and take sole responsibility for getting their research project done in a timely manner.

From the very beginning, I encourage students to design a project that is relatively uncomplicated in nature. After all, this is undergraduate research. The goal here is for students to learn how to conduct quality research and provide them with an experience that might serve as motivation for them to continue doing research throughout their careers. I believe that the more simple and straightforward this initial project is, the smoother their course of development

will be. However, I still find that many students still choose to do projects that are quite labor intensive and time consuming. As a result, this semester often proves to be difficult and stressful for some.

Once students are released to collect their data, I have them continue conferring with me to report on their progress. I allow them a maximum of one month to collect their data. I do make it clear to them at the beginning of the course that the earlier they are cleared to collect their data, the more time they will have to do so. I do allow extensions on a case-by-case basis. This actually happens quite often.

At the end of the course, students submit their data collection sheet and statistical analysis. This allows time for me to provide feedback prior to them presenting their project. This is an important step because this is the last time they get my feedback prior to writing their paper.

The last step in this process is presentation of their project. This is basically an abstract presentation, but much longer. Students present their projects as abstracts (introduction, hypotheses, materials and methods, results, conclusion and discussion) in the time span of 10-20 minutes. It is interesting that at this point, my students want even more time to present their projects.

I begin the mentoring process for new students at this point. The new class of students begin the program at this time and are invited to attend these presentations. While they may not understand the scope of the projects, they will have some insight on where they will be the following year.

Summary:

1. Release meeting to collect data
2. Data collection

3. Presentation of projects to new students

Step four: Writing the paper

The focus of this fourth course is writing the paper. I begin this course with a guest lecture from a medical writer. He explains the "how" of writing the paper. For example, he states that students should write the results (or even the conclusion) section first. He emphasizes that the introduction should not be written first. In fact, he states that the introduction should be written right before the abstract (which is the last section to write).

I require my students to write their paper according to the author information provided by the JNMT. I have my students submit their papers three times. All three submissions are graded as final papers. The first submission is worth the most points (60% of their grade). The second paper is worth 30% of their grade and the third paper is worth 10% of their grade.

I encourage my students to submit their papers as early as possible. I grade papers in the order they are turned in to me. I inform students that it can take up to two weeks to grade their paper. The reason for this is that many students will wait until the due date. If all my students turn their papers in on the due date, it will take 2 full weeks to grade all of them.

I grade the first submission using "track changes." When grading these papers, I provide multiple edits and comments. I tell my students that if there are very few comments and edits, it means one of two things: their paper is EXCELLENT (probably not the case) or their paper is so poorly written that I don't know where to even start without re-writing the entire paper. This assures students when they get their paper back and it has over 100 edits and comments, they know that they are at least close to having a good paper. Students are responsible for addressing all of the edits and comments from this first paper prior to submitting the second paper. I encourage students to meet with me for clarification on specific comments prior to turning in the second paper.

I submit their second papers to an external reviewer for grading. I use the medical writer that gave my students the lecture in the beginning of the course informing them how to write the paper. The second paper is graded based on what is needed for submission for publication. Occasionally, recommendations from the external reviewer are in conflict with my comments from the first paper. When this happens, I award my students extra points if I deducted them on the first submission.

My students must address recommendations from the external reviewer and submit their paper a third time. For this submission, I simply award points if they addressed all of the comments from the second submission. Their paper is now ready for publication. I inform my students privately if I feel their paper is good enough to be submitted for publication. It is then their decision to submit for publication or not. I tell all students that they are still welcome to submit for publication, but if I have not given them a recommendation, they must submit without listing me as an author.

Summary:

1. First paper submitted and graded by instructor
2. Second paper submitted and graded by an external reviewer
3. Third paper submitted and graded by instructor—ready for publication

<u>Step five: Presenting the abstract and mentoring</u>

The final course in my research program is intended to allow students to present their abstracts and mentor new students. As my senior students are preparing their abstracts for presentation, I have them working with the junior students (who are currently on step 2) with their research designs. I have found this mentoring to be beneficial for students as they move from being mentored into a mentoring role.

I provide students several venues to present their research. First, I have them present their abstract to our nuclear medicine physician (who assisted them with their research designs in step 2). This is done in more of a workshop setting where students present their abstracts and feedback is immediately provided.

The second presentation of their abstracts is to the clinical technologists. I obtain VOICE approval for the student abstract presentations and invite all of the technologists from their clinical sites to attend. Many of the technologists have heard from the students about their projects and this is a way for them to see the final product.

The third presentation is to a chapter meeting. We attend the Central Chapter Society of Nuclear Medicine and Molecular Imaging (CCSNMMI) annual meeting each year. Our university also has a research day where students can present their research in the form of a poster. If my students do not wish to travel to the chapter meeting, I require them to present on campus for research day.

Summary:

1. Mentoring new students in their research designs
2. Presentation of abstract:
    a. Nuclear medicine physician
    b. Local technologists
    c. Chapter meeting
    d. Poster presentation at research day

Results

This program has been implemented at IU for four years. There were 25 students who have gone through my research program. All students (100%) presented their research abstracts as part of a continuing education program for technologists. Seventeen of twenty-five

(68%) presented their abstracts at the CCSNMMI annual meeting. Six of twenty-five (24%) presented their research abstracts at the SNMMI national meeting. Three of those six (50%) received travel grants. Two students submitted their research for publication in the JNMT and one was successful.

Conclusion

Nuclear medicine technology educators searching for a way to incorporate research methodologies into their curriculum should allow for creativity. Different programs will employ different ways to add this into the curriculum. The ultimate goal of any research methodology program should be to introduce undergraduates to the research process and instill excitement for new technologists to continue participation in research throughout their career.

Outcome	Learning Objective
1. Utilize information provided by comparative effectiveness research/evidence-based medicine	• Analyze literature to determine applicability to the profession • Demonstrate a working knowledge of regulatory compliance associated with research studies
2. Demonstrate basic concepts of research methods	• Protect and preserve personal and confidential patient information • Comply with current federal, state and institutional regulations • Apply problem solving and critical thinking skills through research activities • Apply the values and ethical principles in relation to research activities
3. Demonstrate effective oral and written communication skills	• Demonstrate technical writing skills • Orally present professional information

TABLE 1 Outcomes and Learning Objectives for NMT Research Methodologies

Research Supervisor Agreement

Each student must have a research supervisor. The research supervisor can be:

- Technologist
- Nurse
- Physician
- Pharmacist
- Physicist

The research supervisor must sign an agreement with the student verifying their involvement in the project. The following are responsibilities of the research supervisor:

<u>The research supervisor:</u>

1. Should provide guidance on the nature of the research, including materials and methods and data collection and analysis.
2. Should be accessible to the student to meet regarding their progress
3. Should ensure the student is aware if their progress is inadequate or unacceptable
4. Should sign the following documents verifying they have been reviewed:
    a. Research proposal/plan
    b. Collected data
    c. Statistical results of collected data
    d. First paper

<u>The student:</u>

1. Should schedule appointments with the supervisor for guidance
2. Must provide the supervisor with the following at least one week before it is due:
    a. Research proposal/plan
    b. Collected data
    c. Statistical results of collected data
    d. First paper
2. Must write the paper independently
3. Is responsible for
    a. Literature review
    b. Data collection
    c. Statistical analysis and forming a conclusion

Student Name _____Date _____

Student Signature _____

Research supervisor name _____Date _____

Research supervisor signature _____

FIGURE 1: Research Supervisor Agreement

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