2016

Chest pain and acute coronary syndrome interactive teaching case: assessment of methodology and achievement of course objectives

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http://hdl.handle.net/2144/19188

Boston University
CHEST PAIN AND ACUTE CORONARY SYNDROME INTERACTIVE
TEACHING CASE: ASSESSMENT OF METHODOLOGY AND
ACHIEVEMENT OF COURSE OBJECTIVES

by

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Submitted in partial fulfillment of the
requirements for the degree of
Master of Science

2016
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I would like to thank my Ana Sofia DeVaney for her continued love and support throughout my education. Without her none of this would be possible. I would like to thank Michael and Lindi Huntsman, Dr. Dzwokai Ma, Douglas Cole Turno, Dr. James Meisel and Mary Warner.
ABSTRACT

Background:
Problem-based learning (PBL) is a pedagogy commonly used in medical education which utilizes small discussion groups led by a facilitator to learn by discussing a problem or case study. Some research suggests that relative to conventional teaching, PBL is more effective in knowledge acquisition and retention due to its emphasis on contextualization and linking concepts, rather than memorization of facts.

Objectives:
The objective of this study is to compare PBL to lecture-based learning (LBL) module in pre-clinical PA and medical students.

Methods:
This is a quasi-experimental crossover interventional study to be conducted with a 1st year PA class and a 2nd year medical school class from Boston University. The students will be assigned to either a control group who will take a LBL module or the interventional group who will take a PBL module. After completing the module the groups will crossover to take the opposing treatment and will be reassessed. The students will take a test at the start of the study, 1 week later before taking either the intervention
or control treatment, another 1 week later prior to the cross treatment and a final test 1 week later. Each test will consist of 20 multiple-choice questions with a corresponding Likert scale question assessing the student level of confidence in their answer choice.

**Results:**

The mean score, standard deviation, confidence interval and variance will be calculated for each test with the medical student and PA student scores combined. The level of knowledge acquisition will be separated between each group and by whether the student is a PA or medical student. The confidence values will be analyzed to determine if there is a relationship with knowledge acquisition in either of the treatments.

**Discussion:**

This study will provide evidence as to whether PBL is superior to LBL in teaching ACS and chest pain to PA and medical students.
TABLE OF CONTENTS

TITLE .................................................................................................................. i
COPYRIGHT PAGE ................................................................................................. ii
READER APPROVAL PAGE .................................................................................... iii
ACKNOWLEDGMENTS .............................................................................................. iv
ABSTRACT ................................................................................................................ v
TABLE OF CONTENTS .......................................................................................... vii
LIST OF FIGURES .................................................................................................. x
LIST OF ABBREVIATIONS ..................................................................................... xi
INTRODUCTION ..................................................................................................... 1
  Background .......................................................................................................... 1
  Statement of the Problem ..................................................................................... 2
  Hypothesis ............................................................................................................ 3
  Objectives and specific aims ............................................................................... 3
REVIEW OF THE LITERATURE ............................................................................. 4
  Overview ............................................................................................................. 4
  PBL and Memory ................................................................................................ 6
  PBL and Learning ............................................................................................... 6
  Differences of Stress and its Effect ....................................................................... 7
Financial Cost of PBL implementation .......................................................... 9
Intangible Barriers to PBL Implementation ................................................. 9
Assessment in PBL Curriculum .................................................................. 10
Improving PBL with Simulation-Based Learning ........................................ 11
Experimental Design .................................................................................. 13
Teaching ACS and Chest Pain ..................................................................... 17

METHODS ....................................................................................................... 19
Study Design ................................................................................................. 19
Test Design .................................................................................................... 20
Study Population and Sampling .................................................................. 21
Lecture Objectives ......................................................................................... 21
Intervention: PBL versus Conventional Lecture Module ............................ 22
Study variables and measures ..................................................................... 23
Recruitment ..................................................................................................... 24
Data collection ............................................................................................... 24
Data analysis ................................................................................................... 24
Timeline and resources ................................................................................ 25
Institutional Review Board .......................................................................... 26

CONCLUSION .................................................................................................. 27
Discussion ....................................................................................................... 27
Summary ......................................................................................................... 28
Clinical and Public Health Significance ....................................................... 28
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Taxonomy of Problem-Based Learning</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Diagram of Research Modalities</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Timeline of</td>
<td>20</td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

ACS ........................................................................................................ Acute Coronary Syndrome
ACLS ........................................................................................................ Advanced Cardiovascular Life Support
BU .............................................................................................................. Boston University
CIHC ........................................................................................................ Canadian Interprofessional Health Collaborative
IPE ............................................................................................................. Interprofessional Education
ISO ........................................................................................................... International Standards Organization
LBL ............................................................................................................ Lecture-Based Learning
OSCE ......................................................................................................... Objective Structured Clinical Examination
PA ............................................................................................................... Physician Assistant
PBL ............................................................................................................. Problem-Based Learning
SP .............................................................................................................. Standardized Patient
TEE ........................................................................................................... Transesophageal Echocardiogram
WHO ......................................................................................................... World Health Organization
INTRODUCTION

Background

Education has historically heavily utilized lecture-based learning (LBL), also referred to in some literature as conventional instruction, however there have been numerous studies and meta-analyses\(^1\) that suggests that problem-based learning (PBL) may be more effective, particularly in medical education from where PBL originated. While many of these studies support PBL as a more effective pedagogy compared to LBL, the results have shown wide variance which has been suspected in part to the manner in which effectiveness was assessed\(^2\).

PBL is a student-center pedagogy which focuses on students solving problems requiring the linking of principles or concepts. In medical education, PBL often involves a case study to educate students which lends itself to topics that rely on related underlying concepts such as chest pain and acute coronary syndrome (ACS). Educating students on the evaluation of chest pain and ACS is important given the potential for significant morbidity and mortality outcomes which are influenced by a practitioner’s ability to recognize key attributes of the different etiologies in a timely manner. The etiologies of chest pain and ACS can present with non-specific characteristics and physical exam findings that are nuanced and at times difficult to appreciate. In order to examine the effectiveness of PBL, a PBL module will be taught to groups of PA and medical students and compared to a traditional LBL module.

Medical education research has often been studied utilizing a non-experimental approach, typically utilizing a group undergoing the intervention followed by a post-test
and with an opposing group taking a pre-test, followed by the intervention and post-test. While often easier to implement compared to other designs, non-experimental design can have multiple threats to validity chiefly the lack of randomization and the lack of a control group which will be discussed in further detail in the following literature review. While randomization can be difficult to address in medical education research, a control group can be implemented in a quasi-experimental design, which will be implemented in this study. This study of PA and medical students taking the same module and assessments will also allow the scores of the PA students and the medical students to be compared. This creates an opportunity to determine if the PA students and medical students have similar levels of competency of ACS and Chest Pain. This information will allow us to infer if they could be taught together in an integrated setting, as touted in the recent academic emphasis on Interprofessional Education (IPE).

**Statement of the Problem**

The purpose of this study is to investigate the effectiveness of PBL compared to conventional LBL in PA and medical students utilizing a novel PBL module on chest pain and ACS. This study will also investigate the statistical significance of student confidence in test answer choices and the correlation to the accuracy in which they are correct.
Hypothesis

If medical and PA students undergo the PBL module then they will demonstrate improved performance and confidence in their post-intervention assessments compared to the students who receive the LBL module.

Objectives and Specific Aims

The overarching objective of this study is focused at garnering better understanding of PBL-based teaching to medical and PA students. In pursuit of this goal, this study will encompass a crossover trial of a PBL and a LBL module. Data collected will be knowledge acquisition and answer choice confidence.

Specific aims of this study are:

1. Compare the knowledge acquisition of students after undergoing a PBL module compared to conventional LBL module.

2. Compare the level of confidence in which students answer questions before and after both PBL and convention LBL instruction modules to determine if there is any significant change.
REVIEW OF THE LITERATURE

Overview

PBL can encompass many different modalities with a common theme that it is a student-centered approach which encourages self-directed learning and enhances the learning through group discussion which help foster multiple links within the memory which are enhance knowledge retrieval. The emphasis on group discussions also highlights why PBL is more effective in small group settings.

PBL has existed in medical education since the 1960s when it was implemented by McMaster University Medical School by Howard Barrows. Barrows described the taxonomy in which he likened PBL as a genus with a number of species, with other branches including lecture-based cases, case-based lectures, case method, modified case-based, problem-based and closed-loop problem based (Figure 1). His summary assessment of each of these branches of PBL contained a list of four chief objectives which were deemed of “primary importance” for the development of medical students: Clinical Reasoning Process, Self-Directed Learning, Structuring in a Clinical Context and Motivation. To summarize the study findings, PBL in general was considered effective however within the different modalities of PBL, however the more effective branches such as closed-loop problem based come at an increased resource cost.
Whether or not there is significant value in PBL has been a topic of debate, however there is a large body of literature, such as the study by Barrows mentioned above, which is supportive that there is inherent value. The proceeding sections will elaborate on PBL in regard to its relationship with learning, memory formation, barriers to implementing PBL, specifically the financial cost associated with implementing and maintaining the curriculum as well as the stress imposed on the students, staff and institution. The remaining sections will give a review of literature surrounding education methodology and testing, as well as literature surround the teaching of ACS and chest pain to medical and PA students.
PBL and Memory

Knowledge is transferred into memory in three stages: sensory memory, short-term memory and long-term memory. The first stage encompasses when sensory input is stored into sensory memory. The sensory memory is theorized to allow the brain time to process simultaneous stimuli allowing the stimuli to be integrated in a continual fashion rather than as a flood of separate pieces. Information that is not provided attention is discarded. If the individual does provide attention to the sensory memory, it can be stored in the short-term memory. Short-term memory allows for temporary retrieval of information from the sensory memory. This information decays rapidly and is discarded in approximately 18 seconds if unrehearsed. The information can be kept in the short-term memory by rehearsing it or it can be transferred into the long-term memory via encoding from where it can be retrieved later. There are different types of encoding, but the one most associated with long-term memory is called semantic encoding which is applied when a sensory input has specific meaning or context rather than being associated with a particular sense, such as smell or hearing. The underpinnings of PBL are in taking advantage of this aspect of memory and asking students to learn concepts in context rather than memorizing facts.

PBL and Learning

The prevailing assumption that PBL encourages learning has been further delineated into surface learning and deep learning by a meta-analysis of 21 programs. The study defines surface learning as “superficial” studying for example for a test or examination primarily
and with little motivation to study underlying factors or concepts. Deep learning was defined as “trying to study what is being studied”. The review found that PBL does indeed increase deep learning, but found it did not make a significant difference in surface learning. The study reported many significant limitations: it only took into account student-reported data from the studies reviewed, only 3 studies reported on the validity of their data and only 8 reported on the reliability.

Further support that PBL is associated with deep learning can be inferred from knowledge retention after school. A meta-analysis performed in 2008 assessed the competencies of physicians whom had graduated from medical schools which utilized PBL compared to other modalities and found that there was strong evidence to support that PBL-trained physicians have increased competency after graduation particularly in the “social and cognitive dimensions” of their assessment. Likewise, a study followed the results of medical students in two PBL schools and compared their results to a traditional curriculum school in both open and closed book progress examinations. The open-book test was used to assess backup knowledge while the closed-book test was used to assess core knowledge. The students in the PBL programs displayed a much higher retention of core knowledge during the closed-book examination and no difference was shown in the retention of backup knowledge in the open-book examination.

**Differences of Stress and its Effect**

As it happens, stress is another facet of distinction between PBL and LBL. A study of PA students in both PBL and LBL programs examined the difference in self-reported mental
stress levels throughout the programs. The study found that students in the PBL programs had statistically significant higher levels of stress not only through their didactic curriculum, but throughout their clinical portion as well\textsuperscript{10}. The researchers cautioned that the increased stress found in PBL cohorts could possibly be attributed to the changing of curriculum both by the program and also the change experienced by students who had no previous experience with PBL requiring them to adapt to the change in studying habits and examination style. Similar types of studies performed on medical students have shown mixed data, with some studies showing increased stress in the PBL cohorts\textsuperscript{11} and other studies showing decreased stress\textsuperscript{12}.

Despite their enhanced education and field of study, medical students, and likely PA students, have a higher level of mental illness attributed to stress compared to the general population. Studies have shown that medical students have a higher rate of suicidal ideation\textsuperscript{13} with 11.2\% reporting contemplation\textsuperscript{14}, 50\% report burnout\textsuperscript{14} and have lower qualities of life compared to general populations. These students also may have a decreased ability to self-recognize the symptoms and are less likely to seek mental health treatment due to the stigma associated with depression\textsuperscript{15}. Aside from encouraging students to lead and promote healthy lifestyles for not only for themselves, but for their patients as well, it is evident that the impact of stress has immense impact on the students and their families during and after school.
Financial Cost of PBL implementation

Cost to value is an important consideration which must be mention when discussing PBL. In respect to the financial cost of implementation on a large scale, a study on medical students at the University of Limerick published in 2009 found that the cost of implementing PBL in the first 2 years was $1,997,191 with an annual reoccurring cost of $868,485. The largest component of this cost was of the professional tutors or staffs that facilitate the discussion which consumed 89% of the reoccurring annual costs\textsuperscript{16}. Due to the amount of time required with instructors, which one study estimated to be 3-4 times as great compared to traditional lecture-based curriculum, PBL becomes increasingly difficult and expensive to implement in groups, especially when class sizes are over 100 students\textsuperscript{8}. While this study is focused on the effectiveness of PBL, the cost or cost-mitigating measures are a topic for future directions. Despite the financial burden imposed by changing curriculum, there have been studies performed in resource-poor countries, such as South Africa\textsuperscript{17} and Uganda\textsuperscript{18}, where medical schools have successfully implemented PBL programs and interestingly have improved retention rates during the clinical clerkships\textsuperscript{17}.

Intangible Barriers to PBL Implementation

Converting a curriculum to PBL has other non-tangible costs in addition to the financial ones already given for the student, staff and the institution. The conversion is a large undertaking which can be difficult and stressful on the staff and the students. In regard to this study specifically, the PA and medical students at BU have a hybrid curriculum
composed of LBL supplemented with small group PBL. The staff faces the burden of creating a new curriculum which is much more time consuming and mentally challenging to prepare when compared to delivering a prepared lecture. The staff must also undergo an ideological shift from instructor to facilitator, a transition that may require additional training and time. There is also a new demand for more facilitators as a conventional lecturer to 200 students will now require a large number of small group facilitators. As more facilitators are required for the small groups, there is inevitably disequilibrium in the distribution of knowledge amongst the facilitators which can be stressful for both the staff and students. The students will also have adjustments to make being forced into discussion groups as their social skills become much more valuable and it may be difficult for some students unaccustomed to working with others.

**Assessment in PBL Curriculum**

PBL is theorized to build knowledge in part by contextualizing concepts previously learned and applying them to appropriate situations which is different that factual memorization utilized in a LBL approach. There are those in the academic community that believe that multiple choice questions are not adequate in assessing knowledge acquired from PBL as it lends itself to factual recall versus applying concepts. Some literature suggests that extended matching set questions is more appropriate\(^9\).

Another argument is that PBL is performed in a group atmosphere and that is not reflected in multiple-choice questions. One approach that has been taken is to use a peer and self-review processes in the assessment. The rationale for using this self and peer-
reviews is that students and teachers have significantly different evaluations for team-working skills as highlighted in a study of engineering students\textsuperscript{20}. As team-work and social skills are critical to a successful discussion group, it seems appropriate to include an assessment that appropriately evaluates this facet of PBL.

However, the self and peer assessment approach is fraught with errors as well. Peer-reviews can suffer from the issue created by students simply having different standards and judgement such as some students will consistently give high scores while others consistently low\textsuperscript{21}. A major issue with the self-review component is that students have been shown to have questionable self-assessment abilities\textsuperscript{22}.

**Improving PBL with Simulation-Based Learning**

An increasingly popular and effective means of enhancing PBL and LBL is the use of Simulation-Based Learning. This teaching modality utilizes simulators, either a full-scale Human Patient Simulators, or a virtual reality environment or a mix of both. Simulators have many advantages as they can mimic real-life encounters by allowing the student to interact with the simulator, for example the student can listen to heart sounds, feel for pulses and even insert IV. Patient simulators also allow students to practice clinical medicine without risking patient lives and allows for consistent repetition. Studies of 4\textsuperscript{th} year medical students have shown students who took simulation-based learning courses performed better than students who took PBL courses\textsuperscript{23}. Not surprisingly, simulator-based learning has been shown to be more effective when compared to LBL in terms of knowledge acquisition and retention\textsuperscript{24}. Another key advantage of the usage of simulators
is to promote enthusiasm within the students. Students who have simulators added to their curriculum, regardless of it being LBL\textsuperscript{25} or PBL\textsuperscript{23}, showed increased enthusiasm for the subject matter.

While most of the literature supports the use of simulator-based learning, there are a few studies which dissent from that position, possibly due to positive reporting bias\textsuperscript{26}. One caveat in present in the body of literature surrounding PBL and simulator-assisted learning is that many of the studies that ascribe themselves as a study of simulator-assisted learning would be considered PBL with simulator-based learning. The ambiguity in defining PBL has been brought up in many reviews and articles and has been a major source of confusion in evaluating these studies. One such study showed no difference in final-year medical students at the University of Toronto taught critical anesthesia scenarios by either video-assisted learning or simulator-assisted learning\textsuperscript{26}. Another negative study was performed on nursing students and showed simulation-based assessment increased self-reported confidence levels without correlating to the acquisition of knowledge\textsuperscript{27}. Other possible drawbacks and limitations to implementing simulators are very limited. The most significant arguments against their use are due to financial cost of the simulators themselves, the cost of training and also there is some concern for the lack of realism in how students approach simulators compared to a real patient. Despite these limitations, there is an abundance of literature to support the integration of simulators into PBL.
Experimental Design

A review of research design and statistics is important in approaching medical education research. Of central importance to these topics is an understanding of internal validity and confounding variables. Internal validity can be defined as the measure by which an outcome is caused by an intervention. In research, the internal validity is compromised by the presence of confounding variables, which are defined as non-experimental variables that have a casual association between an intervention and outcome.

![Research Design Modalities Diagram]

**Figure 2: Diagram of Research Modalities**

There are three broad modalities of quantitative experimental design that were considered to for this study: experimental, non-experimental and quasi-experimental. Each modality has its limitations and strengths which after examining made the use of quasi-experimental design the most pragmatic modality for this study as students taking the course could not be randomized, but it does provide a treatment group versus a control group which is far more robust compared to non-experimental designs many
education studies utilize. Quasi-experimental design uses non-random control groups which by the nature makes the outcomes subject to scrutiny as to whether they are influenced by the intervention or by confounding variables. If the confounding variables are identified, an attempt to control them by distribution can be performed, however it is impossible to identify all possible variables which might affect the study. Quasi-experimental design has been the focus of study for decades because it serves as a more robust means of studying medical education. The more traditional designs, experimental and non-experimental, both have their drawbacks which often make them subpar for medical education. However, quasi-experimental design also has its hindrances which have been identified through meta-analysis\textsuperscript{28} and identified by Shadish\textsuperscript{29} which are listed below:

1. Selection/Randomization: The principle of randomization is to aim for each participant in the study to have equal chance to be in either arm of the study and ideally each arm would have a balance of non-experimental variables. If there are non-experimental variables that are unbalanced in their distribution between the arms, it is possible that they may impart a bias on the groups weakening the validity of the results. Therefore, achieving a balanced through randomization is inversely proportional to the sample size of the study, in other words randomization is ineffective in achieving its goal with small sample sizes. In general, there are three reasons researchers choose not to randomize the intervention\textsuperscript{28}:  

\[ \text{ formula } \]
a. Ethical considerations: While the intervention of this course does not have known efficacy, it can be reasonably assumed that it has a degree of efficacy and at worst would show no efficacy, but very unlikely that it would have a negative effect on the groups. However, a major ethical consideration would be that it would be unfair to give some students more education and therefore to ensure equality, this study will have all students ultimately receive education in both the PBL and LBL modules.

b. Difficulty of Randomizing Subjects: To achieve randomization, half of the class would need to forego the intervention. The prospect of having half of the class not receive a class on a critical topic such as ACS would be difficult to convince both the students and faculty of.

c. Small available sample size: Randomization would also be undesired due to the small number of PA students in a class. By having only half the class undergo the intervention, the power of the study would be dramatically reduced and compromise the significance of the results. The principle of randomization adding significance is grounded on the principle that random confounding influences would be evenly distributed between the different arms of the study in an experimental design, however the likelihood of this occurring diminishes with decreased class size.

2. Regression to the Mean: This statistical phenomenon simply stated is that results tend to even out over time. That is to say that it would be expected for results of
the pre- and post-intervention tests to have smaller variance progressively in time
entirely independent of the intervention.

3. Maturation: The duration between the interventions imposed on G1 and G2 are
question at this point in time. Ideally the duration would be longer to allow for
more data to be ascertained on retention in the post-intervention test, however the
increased duration would allow for other factors to influence the research, most
critically would be the communication between G1 and G2 students and also the
ongoing education and studies of the students. It would not be realistic to advise
the students not to discuss with the class or to cease their studies while this
experiment is underway.

Harris\textsuperscript{28} compiled a table of relative hierarchy of quasi-experimental designs which
delineated the most robust in establishing causality. Per their findings, this study could be
performed using the second-most robust quasi-experimental design possible, which is the
untreated control group design with dependent pretest and posttest samples using
switching replications. The most robust quasi-experimental design being the Interrupted
time-series design, however this design would not be well suited for this study as it
requires far more pre and post-intervention tests which would require much more time to
perform, but would also be confounded heavily by the concurrent education taking place.

One of the objectives of this study is to assess the confidence of the students in
answering. The importance of confidence in assessment has been previous shown to be
linked to knowledge retention\textsuperscript{30}. Studies have shown that students answering correctly
with a low confidence score have a shorter retention rate. Studies performed by Hunt
showed that of the students that had correct answers, but were “Not sure at all” only 25% retained the correct answer one week later. In contrast, student that had the correct answer, but were “Extremely sure” showed 91% retained the correct answer one week later.

**Teaching ACS and Chest Pain**

ACS and chest pain is a broad topic and the latter encompasses cardiogenic, psychogenic, musculoskeletal, gastrointestinal and pulmonary etiologies. The American College of Cardiology estimates that ACS will affect over 780,000 individuals\(^3\) and that more than 70% of ACS incidents will be not be of STEMI etiology which are clinically more difficult to diagnose due to the lack of pathognomonic EKG findings. Similar to their medical student counterparts, PA students are educated how to differentiate and treat ACS and chest pain through their didactic curriculum which often includes an Advanced Cardiovascular Life Support (ACLS) class, such as the one taught by the American Heart Association (AHA). The AHA course requires 12 hours of time to complete and covers the following learning objectives:

1. Basic life support skills, including effective chest compressions, use of a bag-mask device and use of an automated external defibrillator (AED)
2. Recognition and early management of respiratory and cardiac arrest
3. Recognition and early management of peri-arrest conditions such as symptomatic bradycardia
4. Airway management
5. Related pharmacology

6. Management of acute coronary syndromes (ACS) and stroke

7. Effective communication as a member and leader of a resuscitation team

8. Effective Resuscitation Team Dynamics

PA students also receive additional education on ACS and chest pain during clinical skills and didactic courses, however there are no unifying guidelines on the number of course hours or explicit topics to be covered. As broached previous, some PA programs have used simulation-based training to teach cardiopulmonary physical examination and diagnosis skills and reported significantly increased learning and confidence after the intervention\(^\text{31}\). It would be an interesting comparison study a simulation-based approach and PBL in future studies.
METHODS

Study Design

This study will be conducted using a quasi-experimental design. This design was chosen because the groups cannot be truly randomized because limiting chest pain or ACS education would lack equipoise and would be considered negligent. The interventions will be administered in a crossover fashion so that every student is ultimately receiving the same education, but it will be done so at staggered intervals allowing for the comparison of PBL to conventional LBL. PA and medical student classes will be distributed equally to one of two groups: Group 1 (G1), which is the control group, or Group 2 (G2), which is the intervention group. This methodology was chosen to give the highest quality data possible without limiting the education of the students, but still be able to provide a comparison of test scores before28.

G1 will be composed of half the PA student census and half of the med student census with the remaining halves of each class being placed into G2. The study is intended to have a testing assessment immediate prior to both the PBL and the lecture modules. A follow-up test will be administered seven days after the both modules have been completed to evaluate retention.
**Test Design**

The assessments used in this study will be written to assess knowledge acquisition and competency in the topics delineated in the learning objectives listed below. The tests will be of multiple-choice question format and composed of 20 questions. Each test question will have a corresponding Likert Scale with a survey querying the level of confidence with the answer chosen on a scale of 1 to 10, with 10 being certain it is the correct answer and with 1 indicating the student is positive it is an incorrect answer. The results will be analyzed with a paired t-test to determine the p-value indicating the statistical significance of the intervention on improvement of medical and PA student scores. The percent of correct answers will be plotted according to group assignment and by type of student (medical or PA student). The student confidence levels will also be graphed in the

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**Figure 3: Timeline of Events**

<table>
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<tr>
<th>Day</th>
<th>Group 1 (G1)</th>
<th>Group 2 (G2)</th>
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<tbody>
<tr>
<td>Day 1</td>
<td>Test #1</td>
<td>Test #1</td>
</tr>
<tr>
<td>Day 7</td>
<td>Test #2 Lecture Module</td>
<td>Test #2 PBL Module</td>
</tr>
<tr>
<td>Day 14</td>
<td>Test #3 PBL Module</td>
<td>Test #3 Lecture Module</td>
</tr>
<tr>
<td>Day 21</td>
<td>Test #4</td>
<td>Test #4</td>
</tr>
</tbody>
</table>
same fashion. Separate t-test will be performed to determine the significance of more confident answers being correct.

**Study Population and Sampling**

The study population would be the composed of first year PA students from the BU PA class and second year medical students from BU School of Medicine class. Participation in the study would include all students on a voluntary basis. These populations were selected because both classes take many of the same didactic courses together and will have minimal variability in their education related to ACS and chest pain.

**Lecture Objectives**

The Boston University Physician Assistant program learning objectives for their module on ACS and chest pain consists of the following:

1. Differentiate the pain characteristics and clinical presentation of myocardial, aortic, gastrointestinal, pericardial, pulmonary, and musculoskeletal generated “chest pain”.
2. Devise an evaluation plan for a patient with chest pain when given a scenario.
3. Interpret lab and ECG data in order to diagnose myocardial infarction/acute coronary syndrome.
4. Outline the differential diagnosis, treatment and prognosis of chest pain as a result of myocardial infarction, aortic dissection, peptic ulcer disease, pericarditis, pleuritic chest pain and costochondritis.
5. List the indications for transesophageal echocardiogram (TEE), chest tube insertion, pericardiocentesis, and needle thoracentesis.

6. Outline the treatment of hypertensive and hypotensive emergencies.

The learning objectives listed above are directly from the conventional lecture module taught to 1st year PA students prior to embarking on their clinical rotations. This lecture-based module will be used as the control LBL intervention which will be compared to the PBL module. It is important to mention that the PBL course will not focus on two of the above learning objectives listed as #5 and #6 and thus will not be within the scope of the tests administered in this study.

**Intervention: PBL versus Conventional Lecture Module**

The intervention design will be a small group discussion course with approximately 15-20 medical or PA students per session. The PBL module will be implemented in teaching Boston University medical students and PA students. For this study, all of the PBL and LBL sessions will be performed by the same professor to minimize inconsistency in teaching style and content. The structure of the PBL module is delineated into the sequence of events as follows:

1. Introduction to course and summary of structure
2. Administration of Test #3 (for G1) or Test #2 (for G2)
3. Distribution of paper handout (described below) containing Learning Objectives, Part A, B and C
4. Review course learning objectives
5. Case Presentations and Discussion:

6. Review Part A followed by discussion,

7. Review Part B followed by discussion

8. Review Part C followed by discussion

9. Administration of Post-Test 1 to both G1 and G2 sessions

10. Administration of course evaluation

11. Distribution of take-home handout (learning objectives, Part A, B and C with key points from each case)

**Study variables and measures**

There will be two categories of variables that will be collected in this study: (1) knowledge acquisition will be assessed by the number of questions answered correctly on the tests, and (2) the self-reported confidence scores for each question. As discussed in the Treatment section above, the self-reported confidence score will be assessed using a Likert scale ranging from 1 to 10 for each question. A score of 1 would indicate the student has the lowest level of confidence that they answered the question correctly and a score of 10 would indicate the student has the highest level of confidence that they have selected the correct answer choice for that question.
**Recruitment**

Student recruitment in this study will be administered by the BU School of Medicine faculty of the second year medical students and by the BU PA program faculty for the first year PA students.

**Data collection**

The completed tests with their corresponding confidence values will be written directly on the testing forms distributed to the students. The data will be collected in a means to maintain anonymity by having the students leave them without identifying information such as their name, writing side down, at the end of each assessment. The forms will be collected by the instructor of the course and given to the statistician for scoring and data analysis.

**Data analysis**

In this crossover study a 1st year PA school class (~30) and a 2nd year medical school class (~150) from Boston University will be enrolled in a 21 day study prior to commencement to clinical rotations. The groups will be randomized by computer with a goal of equal sex and age distribution.

Each test will have the composite (combined PA and medical student) mean, standard deviation, confidence interval and variance calculated by a consulting statistician with expertise educational research. Results will be compared using a factorial
ANOVA testing. Confidence scores will be plotted with exam scores and examined for correlation.

The data analysis will have the following primary aims:

1. Statistical difference in academic performance prior to intervention
2. Statistical difference in student confidence prior to intervention
3. Statistical difference in academic performance following intervention
4. Statistical difference in student confidence following intervention

Secondary data analysis aims would be:

1. Statistical difference between the medical and PA student groups in academic performance prior to intervention
2. Statistical difference between the medical and PA student groups in student confidence prior to intervention
3. Statistical difference between the medical and PA student groups in academic performance following intervention
4. Statistical difference between the medical and PA student groups in student confidence following intervention

**Timeline and resources**

This study will take place over the course of 4 months in total. A month would be required for preparation of the course materials and scheduling of participants. The experimental phase would have an allotted duration of 21 days with the scripted itinerary referenced Figure 3. The remaining time would be allotted for data analysis. The
resources required for this study will be the staff and materials for the ACS/CP module: instructor, paper handouts of cases, paper for test forms, a classroom with adequate seating for 20 students that allows group interaction (not a lecture hall), and a statistician to be hired for the data analysis.

**Institutional Review Board**

This research would be carried out under the guidance of the Boston University Institutional Review Board. No personal identifiers would be recorded and the research would seek exempt status. If exemption could not be granted, an expedited review will be sought.
CONCLUSION

Discussion

The purpose of this study is to compare the efficacy of PBL to traditional LBL in medical and PA students. Our hypothesis is that students who receive the PBL intervention first will have superior knowledge acquisition and higher confidence in answer choices compared to the LBL group. Further we would expect that the knowledge acquisition and confidence values will be equivalent between the two groups on the final assessment (Test#4) after both have completed the LBL and PBL modules. As pointed out in the review of literature, the manner in which PBL courses are assessed is a source of debate. We have chosen to continue to use the multiple-choice questions as it is the most widely used and studied methodology.

There is a wealth of literature surrounding PBL touting its efficacy, however there is not a consensus that it is more efficacious compared to LBL. A pilot meta-analysis performed by the Campbell Collaboration, a group with similar standards as the Cochrane Review, found little high quality on the effectiveness of PBL. The Campbell Collaboration pilot study also noted that many studies on PBL lacked specificity in describing the specific type of PBL intervention used. In order to address some of the concerns of this pilot study, the design of this study has been selected to provide the most robust data possible.

There are two potentially exciting future directions of study: long term retention and additional comparison of simulation-PBL. Long-term retention studies would need to be carried out at an LBL institution as the crossover design used will have all
participants in this study taking the PBL course. It would be interesting to compare the one-year retention rates as well as the pass rates of the standardized tests (PANCE and STEP 1). The other direction which would be interesting is to compare the PBL intervention used in this study compared to a simulation-based addition to PBL module. It would be easily feasible to convert the case studies into a simulation-based curriculum for future studies.

**Summary**

In summary, this study is a quasi-experimental crossover of comparing PBL and LBL to pre-clinical medical and PA students. The students will be divided a control group who will take the LBL module at the same time as the intervention group takes the PBL module before crossing over into the opposing treatment. The data collected will be the number of questions answered correctly as well as the self-reported confidence score for each question. The students will be assessed 4 times total including prior to the control treatment and intervention. The data received after Test #3 will allow for direct comparison of the PBL treatment versus the LBL control. The data will be examined for correlation with the confidence in which questions were answered to determine if there is a relationship.

**Clinical and Public Health Significance**

The end goal for any medical educator should be to improve clinical outcomes in patients. Though true of many specialties in medicine, ACS and chest pain are prime
examples of when the ability to recall information immediately is key. Better educated clinicians can lead to more expeditious care and accurate diagnosis which would lower the morbidity rate of ACS/CP-related illnesses\textsuperscript{35}. Therefore, it is important that an effort to continually improve the educational system through studies such as this.
LIST OF JOURNAL ABBREVIATIONS

<table>
<thead>
<tr>
<th>Journal Abbreviation</th>
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<tr>
<td>Adv Health Sci Educ</td>
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<td>African Health Sciences</td>
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<td>Journal of Affective Disorders</td>
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<td>Teach Learn Med</td>
<td>Teaching and Learning in Medicine</td>
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</table>
REFERENCES


CURRICULUM VITAE
Christopher Huntsman, PA-S, 1983
1755 Grand Ave • Santa Barbara, CA 93101 • chuntsman@gmail.com • 916.677.9313

EDUCATION

<table>
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<tr>
<th>Degree</th>
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<tbody>
<tr>
<td>Master of Science, Physician Assistant Program</td>
<td>Degree conferred September 2016</td>
<td>Physician Assistant Program, Boston University School of Medicine, Boston, MA</td>
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<tr>
<td>Master of Arts, Molecular, Cellular, and Development Biology</td>
<td>June 2008</td>
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</tr>
<tr>
<td>Bachelor of Science, Biological Sciences</td>
<td>August 2006</td>
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CLINICAL ROTATION

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<td>Internal Medicine (12 weeks)</td>
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<td>Emergency Medicine (4 weeks)</td>
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<td>Boston Medical Center, MA; VA - Manchester, NH</td>
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<td>General &amp; Trauma Surgery (8 weeks)</td>
<td>Roger Williams MC - Providence, RI; BMC, MA</td>
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<tr>
<td>Psychiatry (4 weeks)</td>
<td>VA - Manchester, NH</td>
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WORK EXPERIENCE

- Medical Assistant, Maria Macduff, MD, Family Medicine, Santa Barbara, CA 2012 – 2013
- Senior Project Engineer, Frank M. Booth Design Build Company, Granite Bay, CA 2009-2012
- Biology Teaching Assistant, UC Santa Barbara, Santa Barbara, CA 2006-2008
- Research Associate, UC Santa Barbara, Santa Barbara, CA 2005-2007
- Emergency Department Scribe, Cottage Hospital, Santa Barbara, CA 2007

COMMUNITY SERVICE (OUTREACH)

- Organized & participated in BU collaboration in Homeless Women’s Health Fair 2014-2015
- Participated on an interdisciplinary team at the student-run health clinic in downtown LA 2013
- Medical volunteer and translator during weekend free clinics in Cadaje, Baja California, Mexico 2008-2010

INSTUTIONAL SERVICE

35
Outreach Chair, Student Society of AAPA 2014 - 2016
- Organized and managed Homeless Women’s Health Fair in collaboration with Boston Healthcare for the Homeless

Boston University Representative, Massachusetts Association of Physician Assistants 2014
- Attended monthly meetings, gave program updates and wrote updates for program

AWARDS AND GRANTS
Stipanich Research Scholar. UC Santa Barbara 2006
- Received fellowship to fund the completion of my proposed experiment, *The Role of AGS3 in Pathways that Determine Expression Levels of Ion Channels and Receptors on the Plasma Membrane* (C. Huntsman, 2006), of for the design and execution to elucidate the contribution of a target protein to cocaine-withdrawal symptoms

Distinction in the Major. UC Santa Barbara 2006
- 1 of 20 departmental awards given to undergraduate researchers who complete an honors research thesis. Distinction in the Major was awarded for my thesis entitled, *Role of Potassium Acid Cluster Motifs in Clathrin-Independent Internalization* (C. Huntsman, 2006). The data contained in my thesis was featured in Journal of Biological Chemistry (Qiang Gong, Michael Weide, Christopher Huntsman, Zhuojin Xu, Lily Y. Jan, and Dzwokai Ma. *Identification and characterization of a new class of trafficking motifs for controlling clathrin-independent internalization and recycling*. J Biol Chem. 2007 Mar 1; 17331948). This work was recognized by the Journal of Molecular Medicine who requested an invited review on the dynamic impact our findings had on the field of membrane dynamics (Qiang Gong, Christopher Huntsman, Dzwokai Ma. *Clathrin-independent internalization and recycling*. J Cell Mol Med. 2007 Nov 26; 18039352)

Grant Undergraduate Research and Creative Activities. UC Santa Barbara 2006
- Undergraduate Research and Creative Activities, University of California, Santa Barbara *Role of Potassium Acid Cluster Motifs in Clathrin-Independent Internalization* (Huntsman, Weide, 2006)
- Received $2000 to design and execute an experiment elucidating transport mechanisms for cell surface receptors

PUBLICATIONS AND PRESENTATIONS
• Neuroscience Research Institute Symposium, 2006
• Undergraduate Research and Creative Activities Symposium, 2006

**CERTIFICATIONS & AFFILIATIONS**

<table>
<thead>
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<th>Certification / Affiliation</th>
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<tr>
<td>Physician Assistant License, State of Massachusetts</td>
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<tr>
<td>Certification by the National Commission on Certification of Physician Assistants</td>
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<td>Advanced Cardiac Life Support</td>
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<td>Basic Life Support &amp; CPR</td>
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<td>American Academy of Physician Assistants</td>
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**EXPERIENCE & SKILLS**

Moderate proficiency in medical and conversational Spanish
Advanced proficiency in Microsoft Office Suite, Adobe Acrobat and Bluebeam.
Proficiency in website design and C++ programing.