Problems & Proposals in Graduate School:

A Problem-Based Learning Approach to Doctoral Education in Biomedical Research

Presentation to faculty of University of Toledo
College of Medicine and Life Sciences
May 19, 2017
Steve Triezenberg
VAIGS President and Dean
Objectives for today:

Successful participants will be able to:

• Describe key features of problem-based learning (PBL)
• Recognize advantages of PBL approaches for PhD students in biomedical research programs
• Evaluate whether and how PBL fits with specific grad programs or disciplines
• Brainstorm specific “problems” as prompts for student learning objectives (skills or knowledge) in a given discipline
Our setting:

Single small PhD program; independent charter

*PhD in cellular and molecular biology*

*25 students / 5-7 in each cohort*
Our setting:

Single small PhD program

Housed within a biomedical research institute
(Van Andel Research Institute)

Scientists of research institute =
faculty of graduate school
VARI mission:
*improve health and enhance lives of current and future generations*
Our setting:

Single small PhD program
Housed within a biomedical research institute

We’re young!
First students 2007
First graduates 2012
Initial accreditation 2013
Mission: To train Ph.D. scientists as biomedical research leaders in cell and molecular biology relevant to human diseases with translational emphasis.
VAIGS setting and philosophy:

Mission: Develop biomedical research leaders

Approach: “Think and act like a scientist” (i.e., research leader)
= Combine research skills and leadership skills
The pedagogical problem:

“How do we best help our doctoral students learn what they really need to learn for the work and career that they will come to?”
Stating the pedagogical problem

“How do we best help our doctoral students learn what they really need to learn for the work and career that they will come to?”

- Too much knowledge to know it all
- Access to information is very rapid
- Growth of knowledge is too rapid to keep up
- Telling them all that I know: isn’t the answer.
Not just our issue, and not an entirely new issue:

Walker, Golde, Jones, Bueschel, Hutchings

*The Formation of Scholars* (2008)

Carnegie Foundation for Advancement of Teaching

**Key theme:** “stewards of the discipline”

generating ...   
conserving ...  
transforming ...
Reframing our problem

How do we best help our doctoral students think and act like (research leaders)?
Well ... what do research leaders do?

Take 3 minutes ...

list 4-5 key activities
that define or demonstrate
what research leaders do

(Yes, you may talk with your neighbor.)
What do research leaders do?

Let’s collect a few examples:
What do research leaders do?

Let’s collect a few examples:

Which of those do we want our students to learn to do?

Let’s collect a few examples:

THESE are now our “student learning outcomes”
## Learning outcomes = *aka* core competencies

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Research</th>
<th>Communication</th>
<th>Professional and Ethical Conduct</th>
</tr>
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What do research leaders do?  
AND ... how do research leaders learn?

Take a semester or two of lecture courses...

Read current research papers

Read key review articles

Find a gap that you can exploit

Design a project to hit that gap
Reframing our problem again …

How do we best help our doctoral students learn to do what scholars do, and learn the way that scholars learn?

Carnegie Hall: 

*Practice, practice, practice...*
One approach: Problem-based learning

Common in medical training (nursing, law, business):
“Learn to think like a doctor”

Use a relevant problem to drive learning:

Create the “reason to learn” / “need to know”

Use that context to get to underlying concepts
One approach: Problem-based learning

Common in medical training (nursing, law, business)

Use an **ill-structured (but well-planned) problem** to drive learning:

- Create a authentic “need to know” / “reason to do”
- Set the context for conceptual framework
- Students express what they do (and don’t) know
- Students drive the “learning”; teachers support
Today’s Workshop:

Case study:

Using PBL at Van Andel Institute Grad School

What can YOU learn / apply?
The science we do:

basis of human disease

Cell Biology

Genetics

Epigenetics

Molecular Biology

Biochemistry

Bioinformatics
“What causes pancreatic cancer?”
How can we detect it?
How can we treat it?

Genetics
Biochemistry
Bioinformatics
Molecular Biology
Cell Biology
Epigenetics
Biochemistry
Typical PhD curriculum – Year 1

Biochemistry  
Cell Biology  
Genetics  
Statistics  
Molecular Biology  
Pathology  
Bioinformatics  
Epigenetics
Problem-Based Learning

• Integrate disciplines: \textit{(content, methods)}
  cell and molecular biology, genetics, bioinformatics, pathology, immunology …

• Authentic context for learning:
  Research proposals (grant format)

• Driven by “ill-structured” but well-planned problems in human diseases
Our curriculum - overview

**Fall Semester**
- Cervical Cancer: 3 x 2hr classes, 4 weeks
- Neurofibromatosis
- Brain Cancers
- Parkinsons Dis.

**Winter Semester**
- Leukemia
- Bone disease
- GI Cancers
- Pancreatic Cancer
Our curriculum - overview

• What happens in these modules?
  – Given: A problem relevant to this disease
    *(ill-structured ... unsolved ... well-planned)*
  
  – Task: Research Project Proposal (i.e., grant)
    – “How will you attack that problem?”
      = authentic context for learning!

  – Process: *“Learn whatever you need to learn in order to create / write that proposal”*
Our curriculum – example
Cervical Cancer

• Context:
  – Cervical cancer is caused by human papillomavirus
  – Vaccines are available to block HPV infection
  – Not everyone gets vaccinated before infected

  – Problem: Could we design a therapeutic vaccine – to treat people who have cervical cancer, in contrast to inoculating all pre-adolescents?
Our curriculum – example
Cervical Cancer

— Problem: Could we design a therapeutic vaccine for cervical cancer?

— What would students need to learn?

(input from audience)
Our curriculum - example

Problem: Could we design a therapeutic vaccine?
  – What would students need to learn?

  – INSTRUCTOR has intended learning objectives

  – Plan the “ill-structured” problem and the activities to lead students to achieve those objectives.
PBL at VAIGS

• What happens in these modules?
  – Class meets 3x/week, 2 hours / session

  – What do the STUDENTS do?
    • “What do we need to learn NEXT?”
    • “What do we need to do to learn that?”
      (then go away and do / learn)

    • “What DID we learn since last time?”
Our curriculum - overview

• What happens in these modules?
  – What do the STUDENTS do?
  – What does the PROFESSOR do?

"Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught."

- Oscar Wilde
Our curriculum - overview

• What happens in these modules?
  – What do the STUDENTS do?

  – What does the PROFESSOR do?
    • Help students define new learning issues
    • Provide resources for learning
    • Clarify / correct their new understanding
    • Push for more depth / breadth
    • *Disclose the “intended” learning objectives*
How does PBL address our problem?

“How do we best help our doctoral students learn what they really need to learn for the work and career that they will come to?”

- Too much knowledge to know it all
- Access to information is very rapid
- Growth of knowledge is too rapid to keep up
- They will need to learn (later) more than I know now: transfer is not the answer.
What matters most – the knowledge, or the learning?

“In preparing for battle I have always found that plans are useless, but planning is indispensible.”

- Dwight D. Eisenhower
Our curriculum - overview

• What happens in these modules?
  – Students learn concepts / knowledge
  – Students develop / practice “thinking skills”

How to:  ➤ Define what I need to learn
  ➤ Find information I need
  ➤ Evaluate the quality of that information
  ➤ Find the “gaps in knowledge”
  ➤ Structure the information to make sense
  ➤ Communicate in the style that scientists use
Our curriculum - semester

What happens from one module to next?

Cervical Cancer → Neurofibromatosis → Bone disease → Parkinsons

– Progressive concept development

– Progressive skill development
Our curriculum – whole year

What happens from one module to next?

– Progressive concept development
  • Each module knows and depends on learning objectives in previous modules
  • Self-testing ... spaced repetition ... interleaving topics ... “Make It Stick” (Brown, Roediger, McDaniel, 2014)

– Progressive skill development: practice / feedback how to:
  • Find information you need
  • Evaluate the quality of that information
  • Find the “gaps in knowledge”
  • Structure that information to make sense
  • Communicate in the style that scientists use
What happens to the discipline-specific knowledge?
Curriculum Organizer circos plot
Evidence-based highly effective learning strategies:

- Retrieval practice: recalling from memory
- Spaced repetition of key ideas
- Try to solve before being taught the answer
- Interleave different but related topics
- Testing to judge what was learned
- Build on prior knowledge
- Elaborate in your own words
- Extract ideas, build mental model

How can you use this approach in YOUR setting?

What challenges / issues will you need to address in YOUR setting?
How can YOU use this model?

- Pick a few concepts that students could learn
- Pick a few skills that students should gain

- What kind of “problem” in your discipline could drive students to learn those?

- How would you present that “problem”? (“ill-structured but well-planned”)
How can YOU use this model? (alternative approach)

• Pick an interesting problem in your field

• What are key concepts connected to this problem?

• How could this “problem” be presented so that students learn concepts / gain skills?
How can YOU use this model?

Then put together several such modules

- each with their own problem
- each with their own product / outcome
- progressive development of knowledge
- progressive development of skills
Questions, issues, concerns:

• How to get faculty to stop “teaching” and instead to let students learn

• Defining authentic exercises / activities based on the practice of your discipline

• How to get people “on board” – for a course, for a curriculum
Other questions, issues, concerns:
Resources:

- Brown, Roediger, McDaniel: *Make it Stick*, 2014
More information at:

www.vai.org

Email: gradschool@vai.org
VAIGS Year 1 Curriculum Overview

Strategic Approaches to Biomedical Research (SABR) modules

- Cervical CA
- Neuro
- Bone
- Parkinson's

Historical Perspectives in Biomed Research

Journal Club / Research In prog. / Seminars

Rotation 1
Rotation 2
Rotation 3

Exams

- Leukemia
- Breast/Pros
- Pancreatic
- Brain CA

- Translational Research
- Responsible & Effective
- Conduct of Research

Journal Club / RIP / Seminars

Thesis Mentor Selection / Lab integration week
# VAIGS Core Competencies v2

The student can and does:

<table>
<thead>
<tr>
<th>KNOWLEDGE</th>
<th>Exceptional</th>
<th>Heightened</th>
<th>Advancing</th>
<th>Intermediate</th>
<th>Beginning</th>
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</thead>
<tbody>
<tr>
<td>Describe key concepts in biomedical science</td>
<td>Evaluate new challenges or controversies relevant to concepts</td>
<td>Recognize and apply key concepts as they appear in new settings</td>
<td>Explain concepts with expanded historical and contextual detail</td>
<td>Describe general concepts correctly and clearly</td>
<td>Describe general concepts with gaps and errors</td>
</tr>
<tr>
<td>Place core concepts in the relevant clinical context</td>
<td>Use clinical information to elicit gaps in collective knowledge</td>
<td>Recognize and apply key concepts as they appear in new clinical settings</td>
<td>Connect clinical issues and molecular mechanisms accurately and broadly</td>
<td>Describe clinical context of molecular mechanisms as presented by others</td>
<td>Describe thesis research and disease association in general and limited terms</td>
</tr>
<tr>
<td>Know scientific literature relevant to the research area</td>
<td>Evaluate literature beyond the dissertation research area</td>
<td>Compare contradictory publications in the dissertation research area</td>
<td>Understand and evaluate a primary research article</td>
<td>Understand review article descriptions of emerging concepts</td>
<td>Understand biomedical textbook descriptions of key concepts</td>
</tr>
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<tr>
<th>RESEARCH</th>
<th>Exceptional</th>
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<tr>
<td>Define sound rationale / identify gap in knowledge</td>
<td>Effectively defend given rationale against objections or alternatives</td>
<td>Build expanded rationale for project and experiments</td>
<td>Use rationale to justify priorities for daily work</td>
<td>Understand rationale provided by others</td>
<td>Perform experiments as instructed without considering rationale</td>
</tr>
<tr>
<td>Frame appropriate hypothesis</td>
<td>Recognize alternative and testable hypotheses</td>
<td>Independently generate testable hypotheses coupled with specific aims</td>
<td>Generate independent but incomplete hypotheses</td>
<td>Contribute to formation of hypotheses</td>
<td>Accept hypothesis from others</td>
</tr>
<tr>
<td>Apply creative and appropriate experimental design</td>
<td>Invent and apply alternative strategies and troubleshoots potential outcomes</td>
<td>Critically evaluate and modify approaches</td>
<td>Seek expert advice &amp; glean novel approaches from literature</td>
<td>Collect and employ appropriate approaches</td>
<td>Execute experiments designed by others</td>
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<tr>
<td>Use controls appropriately</td>
<td>Analyze unexpected results and allow new discoveries to emerge</td>
<td>Apply rigorous controls and use outcomes to redirect experimental path</td>
<td>Incorporate both positive and negative controls consistently</td>
<td>Use controls for most approaches</td>
<td>Perform controls as instructed by others</td>
</tr>
<tr>
<td>Execute experiments with technical skill</td>
<td>Generate high technical productivity, publication-quality figures; direct others in technique</td>
<td>Master technical understanding and troubleshoot experimental failures independently</td>
<td>Anticipate results and obtain reproducible results</td>
<td>Exhibit appropriate experimental technique and seek advice when experiments fail</td>
<td>Receive instruction and practice new skills with supervision</td>
</tr>
<tr>
<td>Demonstrate critical analysis and thinking</td>
<td>Defend position or hypothesis-driven experiments to expand the field of study</td>
<td>Compare contrary results, yielding multiple new hypotheses</td>
<td>Observe limits of current models; identify gaps in knowledge</td>
<td>Describe experiments that generated current model</td>
<td>Accept current models as accurate and sufficient</td>
</tr>
<tr>
<td>Integrate results into relevant models</td>
<td>Create new models that integrate experimental findings with external data; Critique data and analysis of others</td>
<td>Revise extant models based on new data from self or others.</td>
<td>Elucidate logical flaws in current models based on experimental data</td>
<td>Compare new data with prior results from self, same lab, other labs</td>
<td>Accept only those results consistent with hypothesis.</td>
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<td>Speak effectively</td>
<td>Elegant communication in multiple settings (conferences, seminars, classroom, mass media, ad hoc).</td>
<td>Present effective poster or platform presentations at conferences; handle questions concisely and effectively; manage logistics and disruptions</td>
<td>Present clear, well-organized research and journal club talks or posters with effective use of schematic and data figures/conclusions</td>
<td>Plan and present journal club or research-in-progress talks for lab or center using simple or pre-set figures</td>
<td>Plan and present short oral summaries in lab meetings or mentor meetings</td>
</tr>
<tr>
<td>Write effectively</td>
<td>Present complex models or proposals using elegant language in multiple formats (essay, grant, research or review article)</td>
<td>Present complex models or rationale in cogent, convincing, and concise language</td>
<td>Build coherent and logical argument describing or proposing research studies</td>
<td>Employ standard structures of scientific communication (poster, manuscript, grant formats) with accurate attribution of citations</td>
<td>Write sentences, paragraphs, and essays using established structure and English language standards</td>
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<td>Communicate to diverse audiences</td>
<td>Communicate science (one's own or other) effectively to varied audiences (scientists, clinicians, lay)</td>
<td>Communicate research effectively to larger and diverse audiences, wider age ranges</td>
<td>Describe research purpose and outcomes to small audience of lay adults</td>
<td>Convey goal, rationale, approach, and outcomes to scientists beyond lab group</td>
<td>Describe experimental purpose and outcomes to lab peers and supervisor</td>
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