Development and Implementation of Hands-On Lab Learning Options for Distance Education Microbiology Students

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Questions to be discussed in this presentation...

• What are the laboratory course options and alternatives for distance education (DE) and online students?

• How do our lab course options meet microbiology curriculum guidelines?

• How should stakeholder (i.e. student, instructor, parent, professional schools, graduate schools) interests be best integrated into development of lab course options?
Summary of MCS DE program

• Started in Fall 2011 → “same” experience as on campus students

• “2+2” hybrid program:
  – community college graduates transfer into the Microbiology and Cell Science (MCS) program as distance education (DE) students to complete their B.S.

• The DE students’ experiences are similar to those of on-campus students:
  – department lecture courses are taught by the same instructors
  – proctored exams
  – same availability to instructors.

• Increased participation of underrepresented minorities in STEM (DE MCS URM > FL state population URM)

• So far, 17 graduates (+6 more expected for Summer 2015)
Fall Enrollment of Transfer Students

*DE begins
**Marketing with Apollidon begins
Underrepresented Minority Participation in Microbiology and Cell Science

FTIC = first time in college (freshman start)
TR = transfer student on-campus
DE = distance education
The DE MCS Program is increasing participation of women

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MCS major: Lab course requirements

**MCB3023L:**

- 2 credit course
- Introduction to microbiology lab skills, scientific method, presentation, research project
- Required for both on-campus and DE students

**“Advanced Lab” requirement:**

- MCB4034L (1 credit course)
  - Advanced molecular microbiology techniques
- Other lab courses accepted (i.e. MCB 5305L, MCB 5136L, CHM4300L, CHM4411L, CHM4413L, SOS4303C)
- Required for both on-campus and DE students
Overall course objectives of MCB4034L (Advanced Microbiology Lab)

1. Gain hands-on experience with several “advanced” microbiology and molecular biology techniques (i.e. isolation of DNA and RNA, real-time PCR, phage transduction)

2. Understand the theory, advantages, and potential limitations of these techniques

3. Perform data analysis & interpretation of experimental results using a variety of software and web-based resources

4. Properly document experiments, results, and data analysis using an electronic laboratory notebook

5. Complete objectives 1-4 in the context of a research project.
MCB4034L research goal: To identify genes required for *Staphylococcus aureus* virulence in *C. elegans*, a model host organism

- Lab experiments (focus on advanced techniques not covered in MCB3023L)
- Documentation of results in Electronic Lab Notebook
- Bioinformatics analysis of DNA sequence data
- Scientific abstract-writing
- Midterm and Final exam
  - Mixture of multiple-choice, short answer
  - Tests ability to troubleshoot experiments, interpret results, critical thinking

**Images not to scale** © from: www.giantmicrobes.com
ASM curriculum guidelines for microbiology lab courses

- Properly **prepare and view specimens** for examination using **microscopy** (bright field and, if possible, phase contrast).
- Use **pure culture** and **selective techniques** to enrich for and **isolate microorganisms**.
- Use appropriate **methods** to identify microorganisms (**media-based**, molecular and serological).
- **Estimate the number of microorganisms** in a sample (using, for example, direct count, viable plate count, and spectrophotometric methods).
- Use appropriate microbiological and molecular **lab equipment and methods**.
- **Practice safe microbiology**, using appropriate protective and emergency procedures.
- **Document and report** on experimental protocols, results and conclusions.

ASM = American Society for Microbiology
Challenge: How to offer equivalent required lab courses to DE students?
Think-Pair-Share Exercise

1. Brainstorm alternative lab course options for DE students that could “match” semester long on-campus labs in terms of learning outcomes
2. Assign the following skills to each alternative lab option

- Formulate hypotheses
- Design experiments
- Analyze and interpret results
- Quantitative reasoning
- Communicate fundamental microbiology concepts (written and oral)
- Interpret and evaluate scientific literature
- Understand relationship between science and society
- Recognize ethical issues in microbiology
- Prepare and view microbiological specimens using microscope
- Enrichment and isolation of microorganisms
- Identification of microorganisms (media, molecular, serological)
- Enumeration of microorganisms (CFU, spectrophotometry)
- Use of microbiological and molecular lab equipment and techniques
- Safety practices
- Documentation of experiments in a lab notebook
Exploration of alternative DE lab options

• Home kits – pros and cons?
  – http://holscience.com/lab-kits/course-descriptions/microbiology/
  – http://latenitelabs.com/
Home lab kit Pros and Cons:

Pros:
• Accessible
• Asynchronous
• Theoretical concepts, experimental design
• Hands-on learning
• Learn from mistakes

Cons:
• Rudimentary “hands-on” learning with respect to equipment/techniques
• Solitary
• Expensive
• Potential safety concerns
• No immediate feedback
• Accepted by professional/graduate school?
Exploration of alternative DE lab options

Virtual Labs:

- [http://learn.genetics.utah.edu/content/labs](http://learn.genetics.utah.edu/content/labs)
- [http://virtuallab.nmsu.edu/micro.php](http://virtuallab.nmsu.edu/micro.php)
- [http://learn.chm.msu.edu/vibl/content/gramstain/gramstain/index.html](http://learn.chm.msu.edu/vibl/content/gramstain/gramstain/index.html)
- [https://www.labster.com/](https://www.labster.com/)
Exploration of alternative DE lab options

https://vimeo.com/136566885
Virtual Lab Pros and Cons:

Pros:
• Accessible
• Economical
• Repeatable
• Asynchronous
• Theoretical concepts, experimental design

Cons:
• Lack of true “hands-on” learning with respect to equipment/techniques
• Solitary
• “Click and Learn”; passive?
• No chance to make mistakes
• Accepted by professional/graduate school?
Virtual Lab – student feedback

• However, it would be really easy to just skip through all the material and get to the questions, meaning that it may not be very conducive to learning effectively.
• It cannot replace the on campus lab!
• Time consuming
• Only as a resource link. It cannot replace a live lab experience.
• It’s unnecessary compared to a video.
• Nice for review before coming into a real lab. It will never be a substitute for the physical kind.
• Yes as a supplement for before the course or for practice during the course.
• I didn’t enjoy the HHMI, I feel like I’ve been just clicking the next button the whole time instead of learning.
• I believe it would help solidify what we did in the lab and allow me to remember it better.
• I don't believe this would be useful to assign before class because it would probably confuse people and you'd just get a lot of questions about it.
Instructional Videos

• MCB3023L Pipetting video: https://vimeo.com/44820191

• Pros and Cons Discussion
Pipetting activity

1. Video tutorial
2. Written instruction
3. Demo in person
WHAT DO WE OFFER TO OUR DE STUDENTS?
MCB3023L DE options

(1) Teaching of MCB3023L *semester-long laboratory* courses at off-campus locations - REC

(2) **Supplementation of equivalent semester-long laboratory courses** (offered at local institutions that will be accepted for credit by the University of Florida) with an online component: Lab bootcamp
   
   Other labs students take (1CR, community college or REC)
   
   Supplement: **Lab skills bootcamp** (1CR, online)

(3) Development of **accelerated immersion lab MCB3023L** courses offered at the Gainesville campus that use the same curriculum and instructors as its semester-long counterpart.
   
   11 days, in an immersion format of 8–10 hour days.
Principles of immersion labs

- Short, very intensive on-campus hands-on lab

- Can be supplemented with distance learning activities

- Supplemented with field trips and other activities
MCB3023L
immersion marathon bootcamp

• 3 years (started in 2013)
• Same materials as semester + field trips and guest speakers, post-lab assignment, reflection and completion of projects
• Compare/contrast semester-long vs. accelerated format
• Enrollment numbers: ~ 10 DE students
  – Graduate student from other departments
  – Transient or post-back student
  – On campus section (2015)

• Student feedback........
How does the MCB3023L immersion lab compare to labs you have previously taken?

DE
• It's easier to absorb the content when it's every day like this class, in reg lab you are given 4 or so experiments to do in 3 hours and all you wind up doing is rushing and memorizing for the tests.
• It has considerably more hands on, more time from Dr. Oli and the TA's dedicated to career advice and guest speakers from the industry. Field trips to laboratories, biotech business incubator companies, and microscopy labs in UF. Dr. Oli genuinely cares that her students get a job after they graduate and progress.
• The techniques learned were very practical.
• It was very fast-paced, and did not have much time to complete all assignments.
• This is the best lab course I have taken.
• Fast paced and not boring. Very high energy and attention from teachers.
• In other labs I've taken we just do experiments and account results. The MCB3023L was that and much more, the teaching staff was fully supportive and welcoming, and while we were constrained on time having to do a poster presentation and speaking in front of class is an invaluable learning experience. The field trips were exciting and very mind opening to the major I'm pursuing. Another difference from other labs for me was that all materials and supplies were readily available and we were able to experiment more outside protocol.
How does the MCB3023L immersion lab compare to labs you have previously taken?

Campus

- Much more, for lack of a better word, immersive. Occassionally fun, even.
- By far surpasses any lab experience I have ever been exposed to. The days flew by and never felt as if they dragged on. I gained more skills and learned more information without the pressures of other classes and time than I could have ever imagined.
- I actually like it a lot... You learn a lot more and it you see results a lot faster
- This lab made me feel a lot less tense and stressed about my grade than other labs I have previously taken, which enabled me to focus on the techniques and concepts I was being taught. I also like the fact that we were given opportunities to boost our grades up. I also liked that many times, we were being taught new things, not for a grade, but for the purpose of being aware of things happening in the real world.
- I thought this was an excellent lab. I was able to learn at my pace, make mistakes, and recieve help when asked.
- A lot more hands on experience * The best lab I have ever taken. *Hands down better than all others.
- *It was more interesting than the other labs I have taken
Would you recommend this lab to other students?

- oh yes!
- yes
- Yes, if they have a car and somewhere they can stay. The truth is the lab ends up costing distance students what would be out of state tuition in expenses even though they're residents.
- Yes of course
- Yes
- Yes!
- absolutely 100%
- Definitely
- Definitely.

- 150%
- yes
- Yes
- Absolutely.
- YES
- Yes
- Yes. I'm somewhat sad it's over.
- yes
Immersion 2015

For 3 of the DE students it was their first lab experience
Advanced lab requirement

• **DE options:**
  – Difficult to offer MCB4034L at distant sites (access to lab equipment, etc.)
  – Immersion lab (on-campus, more on this later...)

– Research experience equivalent
  • “Green light” given by MCB dept. prior to initiation of research – minimum one semester (equivalent contact hours to 1 lab credit)
  • Course credit research preferred (i.e. at REC), but internship or volunteer-based considered (location-dependent)
  • Student must write a final report on their research which is signed by research mentor and submitted to MCB for final approval
  • Number so far?
MCB4034L accelerated lab

• 6-day on-campus labs (morning/afternoon)
  – Midterm on Day 4
  – Final exam ~1 week later via ProctorU or on-campus
  – ELNs, abstract-writing and bioinformatics assignments started during 6-day period; submitted ~1-2 weeks after final exam
  – All lab activities/course content comparable to fall-spring semester format

• Enrollment numbers (DE vs. on-campus)
  – 2013: 5 DE, 12 on-campus
  – 2014: 3 DE, 20 on-campus
  – 2015: 18 DE, 28 on-campus
6-day research project:

Screen *S. aureus* transposon mutant library for virulence factor mutants

- Isolate genomic DNA
- PCR to verify presence of transposon in mutant genome
- Sequencing; Bioinformatics analysis to identify gene mutated by transposon

Transduction of transposon mutants with GFP-plasmid

- Test transposon mutant(s) in an “in vivo” *C. elegans* infection model
- *C. elegans* RNA isolation
- cDNA synthesis
- Real-time PCR and analysis of *C. elegans* immune gene expression
- Fluorescent microscopy to visualize host-pathogen interactions
Final MCB4034L grades (Summer 2015)

On-campus
(n=28)
92.8 ±4.2%

DE
(n=18)
90.3 ±5.0%
MCB4034L student feedback:

• “The accelerated lab course was a great idea and really made me learn the material better. Being put in that accelerated environment made the information easier to remember because we were in lab all day. I would recommend offering the accelerated lab course again.”

• “I enjoyed it and the pace. I only wish the final had been closer in proximity to the actual coursework. Regardless I feel like I learned a lot without being completely overwhelmed.”

• “The term isn't over for almost a month after the due dates of the assignments, it would be nice to have longer to complete some of the assignments, maybe one a week?”
MCB4034L student feedback:

•“The only suggestion I would make for the course is in the future if the first day is going to be a half day to start the course in the afternoon, rather than the morning. For distance students that would enable us to save a night on accommodation if we didn't have to be in Gainesville Sunday night for an early start Monday morning.”

•“For the student who has never participated in research other than school prescribed course work, this lab was very appropriate as it showed a typical design of an experiment in the field relating to pathogens and medicine. In order to best serve the student body, there should be a waiver exempting students from any advanced lab requirements if they can show lab experience accruing to a year or more.”
DE accelerated labs

Pros

• Timing in summer allows students to focus solely on lab course
• “Immersion” learning experience
• 6 or 11-day “away” commitment for DE students
• Access to state of the art equipment
• Fosters collaboration with fellow students (peer learning)
• Fosters interaction with Instructor
• Immediate feedback
• Accepted by professional/graduate schools

Cons

• May be too fast-paced for some students
• 6 or 11-day “away” commitment for DE students may not be feasible
• Financial constraints (travel/accommodation) may limit participation
  – Why we offer the research waiver
HANDS ON EXPERIENCE AND LABS AS PART OF “DISTANCE” HIGHER EDUCATION?
Addressing DE needs and potential “roadblocks” to lab course education

• The non-traditional student in the lab: needs and stumbling blocks (Langie et al, 2010)
  – Survey of 601 students (137 non-traditional)

  http://www.researchgate.net/publication/228597103_The_non-traditional_student_in_the_lab_needs_and_stumbling_blocks

  “44% of these (science and engineering) non-traditional students have problems in attending the mandatory laboratories.... a valuable, flexible alternative for laboratory work is essential. “

  “Almost half of the respondents (43%) have problems with the larger responsibility typical of a laboratory immersion, and 63% fears more work. 82% prefers to work in team during the laboratory immersion. Only 16 out of 137 respondents (12%) prefer the laboratory immersion over the regular laboratories. “
Addressing DE needs and potential “roadblocks” to lab course education

• Hands-On, Simulated, and Remote Laboratories: A Comparative Literature Review (Ma and Nickerson 2006)
  – 60 articles selected for full text review and coding (20 publications each for hands-on labs, simulated labs, remote labs)
  – Most of the literature focused on engineering laboratories
  – No Standard Criteria to Evaluate the Effectiveness of Labwork
  – Advocates and Detractors for Each Lab Type
What are the problems?

**Con Lab**
- Lack of interest in STEM field
- Cookbook lab exercise (not relevant real world material)
- Traditional teaching methods
- Labs are expensive
- No good equipment
- Time consuming
- Safety concerns
- Many professional schools don’t accept virtual labs and online lectures

**Pro Lab**
- Biotech industry needs qualified graduates
- Proficient in cutting edge skills
- Knowledge and use of state of the art equipment
- Part of essential set of knowledge for employees
- Provide students with real life hands on experience
- Make mistakes and learn from it
- Trouble shooting
- Direct supervision and immediate feedback
- Touch, feel, smell
- Meet faculty, deans, mentors, letter writers, peers and TAs
Stakeholder debate: elimination of hands-on learning, online is the future?

Campus students

Distance students

Faculty

Professional school admissions

High school students looking for college admissions

Employer

Graduate school admissions

Administrators

Parents

When making programmatic decisions at UF we need to consider not just administrative or financial aspects, but consider the long term impact for students and feedback from all stakeholders involved.
Take home message

• More than lab skills……..

• Ignite intrinsic motivation, creative and critical thinking in our students and encourage them to think beyond the material taught, rather than simply working for a grade or a degree

• Nersessian [1991]: “hands-on experience is at the heart of science learning”

• Clough [2002]: laboratory experiences “make science come alive.”

• Integrate field trips and career mentoring