ACS minigrant for reform of introductory science.

Interim Report

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How People Learn about Human Development

March 2006-March 2007
$10,000

I. Original goals and objectives

The two most important goals I have for my students are that they learn a few scientific concepts well, and that they learn to think scientifically. The goal of this proposal is to redesign a course in Biology of Human Development (BHD) to incorporate pedagogical approaches based on results from cognitive science. There were three specific objectives.

1) create a portfolio of resources about background information in genetics, cellular, and molecular biology, and embryonic anatomy

2) create a progressive series of interactive classroom exercises for lecture and laboratory using a classroom communication system,

3) develop laboratory experiences that elicit scientific reasoning.

II. Changes in objectives, completed activities, snags, delays.

1) I intended to create a portfolio of resources that would take the place of a textbook. At the time I wrote the proposal, existing texts on human development were either too advanced or too clinical for an undergraduate general education course, and introductory biology texts were too large and too superficial for a course in development. During the summer I discovered that Biological Science by Scott Freeman was available in a three volume set, the first volume of which includes cell biology, genetics, and development. Freeman also takes an experimental approach to instruction that meshes well with my goals. So I adopted Volume I of Biological Science as the primary text for the course.

   I also adopted *Mutants* by Armand LeRoi as a supplemental text. This book is written for a general audience and also takes an experimental approach that studies human mutations as a way to understand how normal development works.

These two books provided enough experiments for us to discuss in class and also provided a structure that would have been missing if I had assigned a series of individual articles as I originally intended. The Freeman text also came with other instructional aids such as text illustrations, a test bank, and animations. The aids were useful for putting together class activities.

The only background sources that I need to assemble from other sources were for human fertilization and assisted reproduction, ethics of cloning, limb development, and sex determination. These I found mostly as chapters from texts in human or general development.

2) I expected to make extensive use of an interactive classroom response system but the software to run our system was too clumsy and difficult to use routinely. Academic Technology on our campus provided me with *Interact* from Quizdom, Inc. and set of 40 RF remotes. The remotes worked perfectly. Students easily logged on and their responses were recorded faithfully. The problem was with the Interact software version they provided for use with Apple's OS X operating system. It did not support cut and paste from other applications properly, so I had to keyboard in every question I wanted to use. That was frustrating since I had a test bank of questions from the textbook publisher ready to use. Instead of it taking 5 minutes to transfer questions it took at least half an hour. The default text was too large and boldfaced and the software would not allow you to change default fonts or sizes, so I had to reformat each question as I typed. In all, it took a huge effort simply to prepare four or five questions. I often did not have enough time or gumption to fight with the software for every class so I did not use the system as much as I expected.

   On the other hand, the students loved using the clickers and most students found them helpful (preliminary assessment results). The most common comments about using the clickers were that it kept them engaged because they knew they were going to be asked questions and they liked knowing how many other students answered the same or differently. They did not like as much having to defend their answers during the think-pair-share sessions.

3) Lab exercises. I was able to develop or adapt several investigative labs.

- Scientific reasoning: the Black Box experiment. Makes explicit the role of hypothesis testing.
- Lac operon: Good example of arguing for an abstraction (gene regulatory network) from experimental evidence.
- Mitochondrial DNA (from the Dolan DNA Learning Center). Elicits conceptual understanding about mutations and is good counter example to patterns of Mendelian inheritance. Connects ideas about genetics and evolution.
- PV92 Alu insertion (from the Dolan DNA Learning Center). Elicits conceptual understanding about mutations

III. Approved budget and financial accounting.

		Approved	Spent
Salary		5000	5000.00
Equipment			
	Mini centrifuge (2)	1260	1763.00
	Electrophoresis set	1040	496.31
	Micropipettors (4 sets of 3)	2700	2684.60
Balance			56.09

IV. Other information

I've attached the course syllabus.

In addition to the activities outlined above, students completed an online Student Assessment of Learning Gains (http://www.wcer.wisc.edu/salgains/instructor/). I have included a summary of those data with this report.

Student Assessment of Learning Gains

Instrument

Biology of Human Development University of Richmond: Biology Bio 104-01 Fall, 2006

Go to your List of Courses Log Out Go to your Course Options

Go back

Your students will see the questions as they appear on this page.

Instructions:
Check one value for each question on each scale. If the question is not applicable, check 'NA'. You may add a comment for any item in the text box at the end of the survey.

Q1: How much did each of the following aspects of the class help your learning?

	NA	No help	A little help	Moderate help	Much help	Very much help
A. The way in which the material was approached	○	○	○	○	○	○
B. How the class activities, labs, reading, and assignments fit together	○	○	○	○	○	○
C. The pace at which we worked	○	○	○	○	○	○
D. The class activities	**NA**	**No help**	**A little help**	**Moderate help**	**Much help**	**Very much help**
1. Class presentations (including lectures)	○	○	○	○	○	○
2. Discussion in class	○	○	○	○	○	○
3. Group work such as brainstorming with big post-it notes	○	○	○	○	○	○
4. Clicker questions	○	○	○	○	○	○
5. Lab exercises	○	○	○	○	○	○
6. The text Biological Science	○	○	○	○	○	○
7. The text Mutants	○	○	○	○	○	○
8. Supplemental readings (pdf files)	○	○	○	○	○	○
E. Tests, graded activities and assignments	**NA**	**No help**	**A little help**	**Moderate help**	**Much help**	**Very much help**
1. Opportunities for in-class review	○	○	○	○	○	○
2. The number and spacing of tests and quizzes	○	○	○	○	○	○
3. The fairness of test content	○	○	○	○	○	○
4. The mental stretch required of us	○	○	○	○	○	○
5. The grading system used	○	○	○	○	○	○
6. The feedback we received	○	○	○	○	○	○
F. Resources	**NA**	**No help**	**A little help**	**Moderate help**	**Much help**	**Very much help**
1. Reading the chapters in Biological Science	○	○	○	○	○	○
2. Study questions at end of chapters	○	○	○	○	○	○
3. Other reading materials	○	○	○	○	○	○
4. use made of the WWW in this class	○	○	○	○	○	○
5. Study Guides	○	○	○	○	○	○
G. The information we were given about	**NA**	**No help**	**A little help**	**Moderate help**	**Much help**	**Very much help**
1. Class activities for each week	○	○	○	○	○	○
2. How parts of the classwork, labs, reading, or assignments related to each other	○	○	○	○	○	○
3. The grading system for the class	○	○	○	○	○	○
H. Individual support as a learner	**NA**	**No help**	**A little help**	**Moderate help**	**Much help**	**Very much help**
1. The quality of contact with the teacher	○	○	○	○	○	○
2. Working with peers outside of class	○	○	○	○	○	○

Q2: As a result of your work in this class, how well do you think that you now understand each of the following?

	NA	Not at all	A little	Somewhat	A lot	A great deal
1. How science is done	○	○	○	○	○	○
2. What genes are and how genes work	○	○	○	○	○	○
3. What mutations are	○	○	○	○	○	○
4. Human embryonic anatomy	○	○	○	○	○	○
5. Time-line of human development, key times in human development	○	○	○	○	○	○
6. Fertilization and assisted reproduction	○	○	○	○	○	○
7. Animal cloning	○	○	○	○	○	○
8. Limb development	○	○	○	○	○	○
9. Sex differentiation	○	○	○	○	○	○
10. Ethical issues in human development	○	○	○	○	○	○
11. Causes of birth defects	○	○	○	○	○	○

Q4: To what extent did you make gains in any of the following as a result of what you did in this class?

	NA	Not at all	A little	Somewhat	A lot	A great deal
1. Understanding the main concepts	○	○	○	○	○	○
2. Understanding the relationship between concepts	○	○	○	○	○	○
3. Understanding the relevance of this field to real world issues	○	○	○	○	○	○
4. Appreciating this field	○	○	○	○	○	○
5. Ability to think through a problem or argument	○	○	○	○	○	○
6. Feeling comfortable with complex ideas	○	○	○	○	○	○
7. Enthusiasm for subject	○	○	○	○	○	○

Q5: How much of the following do you think you will remember and carry with you into other classes or aspects of your life?

	NA	Not at all	A little	Somewhat	A lot	A great deal
1. Understanding the main concepts	○	○	○	○	○	○

Q6: Add comments below

This site was created with funding courtesy of the The ExxonMobil Foundation and the following National Science Foundation-funded projects:

New Traditions (NT) ChemLinks ModularChemistry (MC2)	The National Institute for Science Education	The AAC&U SENCER Institutes

Student Assessment of Learning Gains

The Big Picture of

Biology of Human Development University of Richmond: Biology Bio 104-01 Fall, 2006

Go to your List of Courses Log Out Go to your Course Options

Average over entire instrument for those giving 1-5 responses *

Average	Standard Deviation
3.13	0.98

Average by question for those giving 1-5 responses *

Question	Average	Standard Deviation
1. How much did each of the following aspects of the class help your learning?	3.09	1.02
2. As a result of your work in this class, how well do you think that you now understand each of the following?	3.34	0.86
4. To what extent did you make gains in any of the following as a result of what you did in this class?	3	0.98
5. How much of the following do you think you will remember and carry with you into other classes or aspects of your life?	2.8	1.08

Average by aspects of question 1 for those giving 1-5 responses *

Aspect	Average	Standard Deviation
A. The way in which the material was approached	3.14	0.76
B. How the class activities, labs, reading, and assignments fit together	3	0.96
C. The pace at which we worked	2.78	1.02
D. The class activities	3.09	1.03
E. Tests, graded activities and assignments	2.82	1.08
F. Resources	3.37	0.92
G. The information we were given about	3.1	0.87
H. Individual support as a learner	3.33	1.15

* The averages in each table were constructed as follows: Those answers which students selected as "Not Applicable" or did not provide an answer were removed from the total set of responses. The average was then computed over the total set of responses to the applicable questions which had a 1-5 value.

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Student Assessment of Learning Gains

View Course Responses

Biology of Human Development University of Richmond: Biology Bio 104-01 Fall, 2006

Go to your List of Courses Log Out Go to your Course Options

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	NA	1	2	3	4	5	total	ave (stdev)	NR
Q1A	0%	0%	19%	50%	28%	3%	36	3.14 (0.75)	0
Q1B	0%	6%	25%	36%	31%	3%	36	3 (0.94)	0
Q1C	0%	14%	19%	44%	19%	3%	36	2.78 (1)	0
Q1D.1	0%	0%	22%	36%	22%	19%	36	3.39 (1.03)	0
Q1D.2	3%	6%	22%	39%	25%	6%	36	3.03 (0.97)	0
Q1D.3	0%	0%	31%	25%	36%	8%	36	3.22 (0.97)	0
Q1D.4	0%	6%	11%	33%	39%	11%	36	3.39 (1.01)	0
Q1D.5	0%	8%	22%	39%	31%	0%	36	2.92 (0.92)	0
Q1D.6	0%	6%	3%	39%	31%	22%	36	3.61 (1.03)	0
Q1D.7	3%	14%	50%	22%	8%	3%	36	2.34 (0.92)	0
Q1D.8	0%	0%	37%	46%	17%	0%	35	2.8 (0.71)	1
Q1E.1	0%	11%	22%	36%	25%	6%	36	2.92 (1.06)	0
Q1E.2	0%	8%	31%	25%	33%	3%	36	2.92 (1.04)	0
Q1E.3	0%	25%	36%	22%	11%	6%	36	2.36 (1.13)	0
Q1E.4	3%	15%	24%	36%	18%	3%	33	2.69 (1.04)	3
Q1E.5	0%	3%	25%	47%	22%	3%	36	2.97 (0.83)	0
Q1E.6	0%	11%	19%	33%	25%	11%	36	3.06 (1.15)	0
Q1F.1	0%	3%	8%	44%	33%	11%	36	3.42 (0.89)	0
Q1F.2	0%	0%	11%	47%	25%	17%	36	3.47 (0.9)	0
Q1F.3	0%	0%	31%	56%	11%	3%	36	2.86 (0.71)	0
Q1F.4	0%	3%	19%	47%	28%	3%	36	3.08 (0.83)	0
Q1F.5	0%	0%	6%	17%	50%	28%	36	4 (0.82)	0
Q1G.1	0%	0%	28%	42%	25%	6%	36	3.08 (0.86)	0
Q1G.2	0%	3%	22%	39%	33%	3%	36	3.11 (0.87)	0
Q1G.3	0%	6%	14%	47%	31%	3%	36	3.11 (0.87)	0
Q1H.1	3%	0%	17%	31%	36%	14%	36	3.49 (0.94)	0
Q1H.2	6%	11%	22%	17%	28%	17%	36	3.18 (1.29)	0
Q2.1	0%	0%	19%	25%	44%	11%	36	3.47 (0.93)	0
Q2.2	0%	6%	6%	39%	44%	6%	36	3.39 (0.89)	0
Q2.3	0%	0%	8%	33%	47%	11%	36	3.61 (0.79)	0
Q2.4	0%	6%	14%	44%	31%	6%	36	3.17 (0.93)	0
Q2.5	0%	0%	19%	44%	31%	6%	36	3.22 (0.82)	0
Q2.6	0%	0%	11%	25%	61%	3%	36	3.56 (0.72)	0
Q2.7	0%	3%	19%	47%	28%	3%	36	3.08 (0.83)	0
Q2.8	0%	0%	19%	50%	28%	3%	36	3.14 (0.75)	0
Q2.9	0%	0%	11%	44%	42%	3%	36	3.36 (0.71)	0
Q2.10	0%	0%	17%	31%	42%	11%	36	3.47 (0.9)	0
Q2.11	0%	6%	14%	31%	47%	3%	36	3.28 (0.93)	0
Q4.1	0%	3%	17%	44%	28%	8%	36	3.22 (0.92)	0
Q4.2	0%	3%	22%	47%	25%	3%	36	3.03 (0.83)	0
Q4.3	0%	6%	11%	33%	50%	0%	36	3.28 (0.87)	0
Q4.4	0%	3%	17%	36%	42%	3%	36	3.25 (0.86)	0
Q4.5	0%	6%	26%	34%	31%	3%	35	3 (0.96)	1

Q4.6	0%	17%	22%	42%	17%	3%	36	2.67 (1.03)	0
Q4.7	0%	20%	26%	34%	17%	3%	35	2.57 (1.08)	1
Q5.1	0%	9%	37%	26%	23%	6%	35	2.8 (1.06)	1
2143184739	0%	0%	0%	0%	0%	0%	0	0 (0)	36

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Biology of Human Development

Biology 104

Biology 104, Fall 2006

Lecture: MWF 8:15-9:05, Gottwald A201

Labs: R 9-11am or 1:30-3:30 Gottwald B102

Dr. Gary Radice

Office: Gottwald B116, hours by appointment, just ask!

Phone: x8107 or x8228

E-mail: gradice@richmond.edu

Class web site: blackboard.richmond.edu

Text: Scott Freeman, *Biological Sciences*, Vol 1.
Armand Marie Leroi *Mutants*.

Additional readings available as downloads from course web site or UR library as assigned.

Safety Glasses: available in the bookstore

Overview

It is an exciting time to be studying human development. Recent advances in microscopy, genetics, molecular biology, cell biology, and evolution have given developmental biologists a wealth of tools for answering some of the oldest questions about how life begins and grows: When does human life begin? How identical are "identical" twins? If every cell in the body has the same DNA, why aren't all cells alike? How does sexual differentiation happen? And now, in the 21st century, we have a range of new questions to ask as well. Can people be cloned? Can we make new body parts from stem cells? How genetically different are individuals? Can we select the sex of our offspring? What changes in development happened to create new species? Can we safely trade genes between different species?

This course will examine the science behind some of the more thought-proving ideas raised by advances in developmental biology. In one semester we cannot address all of the biology of human development nor can we address all of the ethical and cultural issues raised by recent advances. Instead, we will limit our discussion to a few topics and go into them in some depth. We will go into some of the experiments in a fair amount of detail. I am mostly interested in your ability to understand the **logic** of the experiments rather than arcane details. A major goal of the course is to learn about

scientific reasoning and how science works, and we will use examples from developmental biology to illustrate these concepts. For example, we will talk about how to generate a hypothesis, make predictions that could test that hypothesis, and design experiments to test those predictions. We will talk about the nature of evidence, and what qualifies as a scientific test.

This course fulfills the UR field of study requirement for natural science (FSNB). It is intended for students who do not plan to major in a natural science. I assume that most of you have not taken other college level science, but that you have all had high school chemistry and biology. If you have *not* had high school chemistry and biology, please let me know.

Format

The class is based on active learning, which means that there will be relatively little lecturing. Instead, you will spend class time in discussion, working problems, and self-assessment using "clickers." This approach is known to help students learn science better than by listening to lectures. *It absolutely requires that you complete readings and assignments before you come to class*.

Lab days will include a mix of lab work, observation, computer work, and discussion. There is no lab book. You will work from handout in lab or info available on the web.

Special note: **as of August 2006, all students in biology and chemistry labs must have approved safety glasses or goggles that meet or surpass the "ANSI Z87.1" standard for high impact. You must have them with you in lab. These may be purchased in the bookstore.**

Clickers

The course will provide electronic response pads ("clickers") to encourage your participation and to help you (and me) assess your understanding as we go along. Most often they will be used to record your answers to multiple choice questions during class. We will use these nearly every day of class, and one question each day will count toward your participation grade. It is important that you use the *same clicker* every day, so that you receive credit for your participation. Never switch clickers with another student. Doing so is an honor code violation for which you will immediately fail the course.

I will start collecting participation grades during the third week of class. At that point, you will receive three points for every correct answer, and two points if you get it wrong but participate. I will drop your three lowest grades for the semester to account for broken clickers or occasional excused absence. Participation will count for approximately 10% of your course grade. (To give you some idea how this works: there are 42 class days. We won't collect participation grades until the third week or on quiz or exam days, so that leaves will be about 24 class days eligible for participation,

minus your three lowest responses equals about 21 participation questions eligible for grading. Answering them all correctly will add 3x21=63 points to your course grade. Answering them all, but incorrectly, adds 2 x 21 = 42. Not answering adds no points.

Assessment and Evaluation

Learning has many different aspects. One widely used scheme for thinking about learning includes the following attributes.

- Remembering: recognize, recall, describe, identify, name
- Understanding: interpret, summarize, infer, paraphrase
- Applying: implement, carry out, use in another situation
- Analyzing: compare, organize, deconstruct, differentiate
- Evaluating: judge, critique, justify
- Creating: design, construct, plan, generate new knowledge or ideas

The quizzes, exams, and assignments are designed to assess your progress in each of these areas. Many of the assessments will be "no credit," so that you can judge your progress as we go along, before you get to a quiz or exam. Quizzes and exams will be similar to the no credit assessments.

Grades will be based on:

- Quizzes: 7 x 20 points, mostly short answer/MC questions about the readings and lecture topics
- Exams: 2 x 100 points, midterm and final, mostly short answer
- Lab quizzes: 20 or 30 points, total 170
- Analysis of scientific review article: 2 x 20 points, analysis of an experiment in developmental biology of your choice
- Participation: 63 points

There is a total of 613 points possible. Your final course grade will be based on the percentage of the total you acquire. The scale is 97% or above (595) for an A^+, 93–96% (570–594) for an A, 90–92% for an A^-, 87–89% for a B^+, 83-86% for a B, and so on. There is no "curve."

Course Assessment

I constantly try to improve the courses I teach. One of the best way for me to do this is to get feedback from you about what works and what doesn't work, and why. Near the beginning and end of the course there will be a couple of short surveys for you to complete that will help me evaluate the course.

Attendance Policy

Attendance is required for all quizzes and exams. In general, there are no make-up exams. However, if you know ahead of time that you have a legitimate reason to be absent for an exam, see me and we may be able to arrange an alternate time for you. If you simply do not show up for an exam or quiz, you will not be allowed to take it at another time. **Please note that this policy includes those days around Fall Break, Thanksgiving and Semester Break. It is your responsibility to arrange your travel plans according to your course schedule. Do not ask me to change the course schedule to accommodate your travel plans!**

Apart from exam and quiz days, attendance is not required. HOWEVER, about 10 percent of your grade will be based on participation, the class moves fast, and if you miss something *you* are responsible for learning what happened that day. Do not expect me to spend extra time with you outside of class making up material I have already covered in class. I will enthusiastically help anyone who attends regularly, participates, and works hard.

Honor Code

We expect everyone to abide by the conventions of the Honor Code. In this class I also strongly encourage you to study together and help each other learn. But when it comes times for assessment, all exams and quizzes must be solely your own work.

Some of the work you do will require using the lab computers. You may use the lab computers any time the lab is open. I expect everyone to abide by the University's policies regarding ethical uses of computers.

In addition, there are certain practices in this class that I will not tolerate and could result in automatic failure of the class:

1. Never switch clickers with another student. Doing so is an honor code violation for which you will immediately fail the course.
2. Do not make personal copies any of the software on the lab computers. The only exception is **ImageJ,** which is in the public domain and can be copied freely. Available from http://rsb.info.nih.gov/ij/.
3. Don't remove or alter anyone else's files! Especially don't modify any of the programs or system files. Do **NOT** add any games or other software. Any unauthorized software or documents will be removed without warning.
4. We have limited disk space. Please don't exceed the space allotted to your group or to your laptop. Digital images take up a lot of space, so discard any unnecessary images regularly.

5. Don’t remove any of the computers, including laptops, peripheral equipment, or training manuals from the classroom. The only exception is your own personal disks.
6. The computers are connected to the campus network, and you are welcome to use them to log onto the network as you would from any other campus public site. Do not abuse the privilege, however. And please log off if there are others waiting for the machines to do work for this course.

Course Schedule

Week (# of classes)	Topic	LeRoi	Freeman	Activities, other readings	Quiz or Exam	Laboratory
August 28 (3)	Overview, and how to study development	Ch 1	Ch 1	Lee Ch 9 Gilbert Ch 1		Name game. lab orientation
	Science, non-science, pseudoscience			Clicker training		VNOS 20
September 4 (3)	Meiosis, fertilization, blastomere formation	Ch 1	Ch 12, 21	Gilbert Ch 2 Concept map	Quiz 20	Black box and scientific thinking
	Genomic equivalence and cloning			training		Lab quiz 20
11 (3)	Cloning and stem cells			Gilbert Ch 3	Quiz 20	The scientific literature
18 (3)	Gastrulation and neurulation	Ch 2	Ch 21		Quiz 20	Fertilize frog eggs, and/or movie of development. Visembryo.com
25 (3)	What is a gene? What is a mutation?	Ch 1& 2	Ch 13	Gilbert Ch 13	Quiz 20	Gastrulation/neurulation movies
						Lab quiz 20
October 2 (3)	What is a gene? What is a mutation?	Ch 1& 2	Ch 13		Paper analysis 20	Lac operon lab
9 (3)	Central Dogma, role of DNA, RNA, and Protein		Ch 3, 4	Sean Carroll seminar, afternoon and evening	Midterm 100	Lac operon lab
18 (2)	Central Dogma, role of DNA, RNA, and Protein		Ch 15, 16			Lac operon lab
						Lab quiz 30
23 (3)	Differentiation and regulation of gene expression: how are genes regulated? Cis sequences	Ch 3	Ch 17, 18		Quiz 20	Mitochondrial DNA lab
30 (3)	Differentiation and regulation of gene expression: how are genes regulated? Transcription factors	Ch 3	Ch 22		Quiz 20	Mitochondrial DNA lab
November 6 (3)	Cell-Cell signaling	Ch 10	Ch 8.3 Ch 22	Doug Fields seminar, Brain Development	Quiz 20	Mitochondrial DNA lab
						Lab quiz 30
13 (3)	Axis and pattern formation	Ch 4, 5	Ch 22			Alu insertion PCR
20 (1)	Limb formation	Ch 6		Supplemental Reading	Paper analysis 20	No Lab Thanksgiving Break
27 (3)	Sex determination	Ch 7		Supplemental Reading		Alu insertion: Electrophoresis & Discussion Lab quiz 30
December 4 (3)	Evolution of development	Ch 10		Supplemental Reading		VNOS 20
Dec 11	Final exam 2-5 pm, Lab 02 (option)				Final 100	
12	Final exam 2-5 pm Lecture (prefered)					
19	Final exam 2-5 pm Lab 01 (option)					