

Formative Assessment and Flipped Classroom

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SCHOOL OF MATHEMATICAL & STATISTICAL SCIENCES

“All theory is grey ,my friend, but forever green is the tree of life ” - Wolfgang von Goethe .

Pilot Course for Biomedical Calculus – taught in Fall 2016 as flipped class

Biomedical Calculus curriculum design and development (Spring 2016-Summer2017)

Linear Algebra - taught in Fall 2016 as flipped class

Laboratory component in calculus curriculum: labs designed for specific majors in STEM fields (engineering, chemistry, computer science, biology)

Collegiate Mathematics Teaching (in flipped classroom environment): graduate elective course in mathematics education curriculum (Spring 2017)

Lecture Based Teaching vs. Flipped Classroom

Traditional Lecture Based

Lecture

Reading assignment (reinforcing lecture content) and/or assignment to watch video clip(s)

Homework based on lectures and reading

Midterm exam

Final exam

Random quiz prior to a lecture on the previous lecture material

Flipped Classroom

- Reading assignment(s) and/or assignment to watch video clip(s)
- Quiz on the previous assignment
- No formal lecture in classroom
- Group work in classroom (more than 75% of classroom time)
- Group work continues outside the classroom
- Midterm exam
- Final exam

Active Learning and Flipped Classroom

What is active learning?

- Inquiry Based Learning?
 - Challenge Based Learning?
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Need to be compared with traditional lecture based instruction

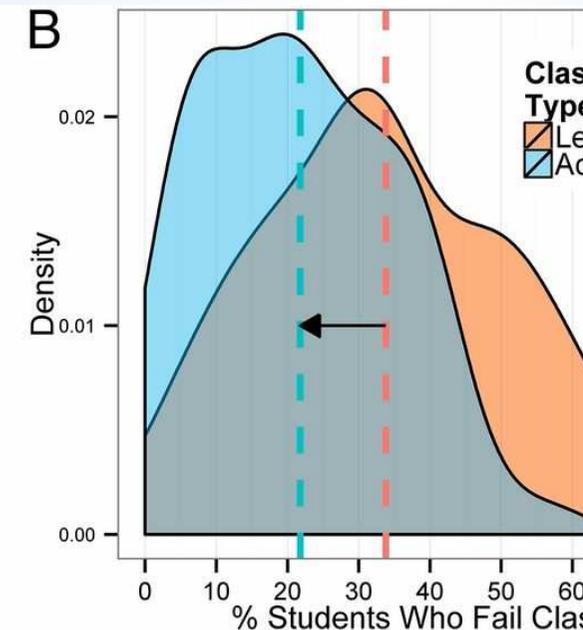
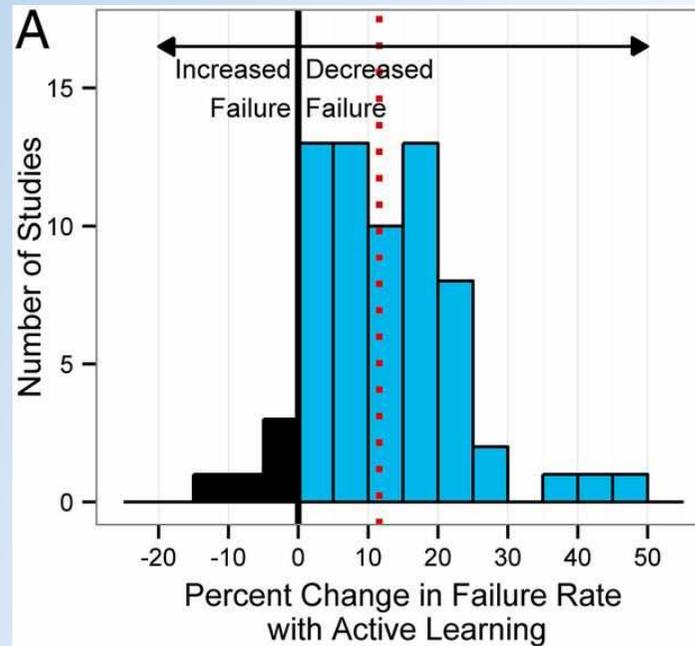
What is happening in the classroom

Flipped Classroom

1. No lecture
2. Students work In the classroom
3. Students work in teams
4. Has elements of inquire based learning
5. Has elements of challenge based instruction

Freeman S., Eddy S.L., McDonough M., Smith M.K., Okoroafor N., Jordt. H., and Weneroth M.P. (2014). Active learning increase student performance in science, engineering, and mathematics. Proc. Natl. Acad. Sci. USA. 111(23) 8410-8415

Learning is considered to be active if students are engaged in meaningful learning activities that require higher-order thinking, rather than just listening, and are provided a learning environment that enables the development of skills, rather than just absorption of information [Bonwell & Eison, 1991]; [Winstone&Millward, 2012]



Four Components of Curriculum Development [Taylor 1949]

Objectives -->Content -->Teaching Strategies-->Assessment

Teaching strategies: lecture based.
Main focus of curriculum development

- Lecture content
- Summative assessment

Teaching strategies: flipped (active learning)
Main focus of curriculum development

- Objectives
- Formative assessment
- “Content” including organization and guiding students activities
- Summative assessment

Formative Assessment and Summative Assessment

- Formative assessment (student focused)

“Information communicated to learner that is intended to modify his or her thinking or behavior for the purpose of improving learning” [Shute, 2008]

- Formative assessment (instructor/instruction focused)

“Formative assessment is generally defined as assessment for the purposes of instruction” [Heritage et al., 2008]

Two Dimensional Bloom's Taxonomy [Anderson et al.,2001]

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Metacognitive Knowledge						

Andrew C. Porter and John L. Smithson. Defining, Developing, and Using Curriculum Indicators. CPRE Research Report Series RR-048, December 2001. Consortium for Policy Research in Education University of Pennsylvania Graduate School of Education. <https://secure.wceruw.org/seconline/Reference/rr48.pdf> -

Formative Assessment Methods and Bloom's Taxonomy [McConnell, Steer&Owens, 2003]

		Learning Tool (Assessment Method)					
Bloom's Taxonomy	Learning Skill	Concept Test	Venn Diagram	Image Analysis	Concept Map	Open-ended Question	Evaluation Rubric
Knowledge	memorization and recall	X	X	X	X	X	X
Comprehension	understanding	X	X	X	X	X	X
Application	using knowledge	X	X	X	X	X	X
Analysis	taking apart information		X	X	X	X	X
Synthesis	reorganizing information				X	X	X
Evaluation	making judgements					X	X

Two Dimensional Bloom's Taxonomy And Traditional Lecture Based Mode

	Remember	Understand	Apply	Analyze	Evaluate	Create
Lecture			+ presented by an instructor	+ presented by an instructor	+/- presented by an instructor	
Homework			+	+	+	
Reading Video		+	+	+		
Assessment	-	-	summative	summative	summative	

Formative Assessment and Flipped Classroom

- Efficacy of assessment depends:
 - on motive (students' need),
 - means (students are willing and able to use it),
 - and opportunity (students receive it in time to use it) [Shute, 2008]
- Assessment can employ three main methods for gathering data, namely , observation, test/(exam, MB) and clinical interview [Piaget, 1976].

Level of Objectives/Outcomes. Lecture Based Teaching

At the Course Level

Low-Division ACGM. - Upon successful completion of course, students will:

Develop solutions for tangent and area problems using the concepts of limits, derivatives, and integrals.

Draw graphs of algebraic and transcendental functions considering limits, continuity, and differentiability at a point.

Determine whether a function is continuous and/or differentiable at a point using limits.

Use differentiation rules to differentiate algebraic and transcendental functions.

Identify appropriate calculus concepts and techniques to provide mathematical models of real-world situations and determine solutions to applied problems.

Evaluate definite integrals using the Fundamental Theorem of Calculus.

At Modules Level

- Corresponds to summative assessment

Competency-Subunit's Outcome-Level of Assessment

	Unit – Subunit	Level of Assessment	Competency: Apply knowledge of mathematical biology, biochemistry, physics, and chemistry understanding living systems.
<i>Module 1: Limits and continuity</i>	Unit 2 Subunit 1	Apply, Analyze	Discuss intuitive concept of limit: classify points of a function domain where limit exists and does not exist; estimate a value of a limit; argue why limit does not exist
<i>Module 1: Limits and continuity</i>	Unit 2 Subunit 1	Remember Understand	Discuss intuitive concept of one-sided limit: classify points of a function domain where one-sided limit exists and does not exist; estimate a value of a one-sided limit; connect the concept of limit and one-sided limit

Assessment with Developed Instruments I

	Metacognition Quiz	CFU/ Quiz	Practice Problems	Specialized Lab	Post Module Exam	Final Exam
Qual Knowledge		X				
Conceptual Knowledge	X	X	X		X	X
Procedural Knowledge			X	X	X	X
Metacognitive Knowledge	X			X		X

Bloom's Taxonomy & Developed Instruments

	Metacognition Quiz	CFU/ Quiz	Practice Problems	Specialized Lab	Post Module Exam	Final Exam
Remember		X				
Understand	X	X	X			X
Apply			X		X	X
Analyze			X	X	X	X
Evaluate	X			X		
Create						

Guiding Students through Activities

The screenshot shows a mobile application interface on an iPad. At the top, it displays 'iPad', signal strength, '11:06 AM', and '73%' battery. Below the status bar is an 'EXIT' button. The main title is '2.1 Concept of Derivatives and Basic Rules of Differentiation'. A progress bar shows '0/0 Points'. A horizontal line with five icons (a green circle with a checkmark, a white circle, a white hexagon, a white hexagon, and a white circle) represents the course structure. Below the icons are labels: 'My Unit Plan', 'Learn about Differentiation Rules and Higher Order Derivatives', 'Check for Understanding', '2.1.1 Practice Set: Definition of a Derivative', and 'Learn about Differentiation Rule and Higher Order Derivatives'. At the bottom, a statistics bar shows: '0/0 ASSIGNMENTS', '0/1 QUIZZES', 'Pts 0/0 POINTS', '0/1 ATTEMPTS', and 'N/A DUE DATE'. A large green 'BEGIN' button is centered at the bottom.

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Assessment of Four Subunits in the Course

	Metacognition Quiz	CFU/ Quiz	Practice Problems	Specialized Lab	Post Module Exam	Final
Unit1 unit 1	X	X	X			
Unit1 unit 2		X	X		X	X
Unit 2 unit 1	X	X		X	X	X
Unit2 unit 2		X	X	X		

Specialized Labs by Major

Biology	<ul style="list-style-type: none"> • amount of ozone in atmosphere (derivative as function) • weight growth for male yellow baboons (derivative as rate of change) • high blood pressure (the chain rule) • oil spill (antiderivative)
Chemistry	<ul style="list-style-type: none"> • rate of radioactive decay (derivative as rate of change) • linear momentum operator in quantum chemistry (derivatives of trigonometric functions)
Computer Science	<ul style="list-style-type: none"> • efficiency of algorithms (de L'Hopital Rule) • projectiles in computer games (second derivative) • image differential and integral (derivative and integral)
Engineering	<ul style="list-style-type: none"> • first-order RC circuits (derivative as rate of change) • electric charge (derivative as rate of change) • current (derivative as rate of change) • voltage (derivative as rate of change) • capacitors (derivative as rate of change)
Physics	<ul style="list-style-type: none"> • motion in one dimension (derivative as rate of change) • geometrical optics (derivatives of trigonometric functions) • work done by a force (integral) • finding position function from acceleration (second derivative) • Newtonian gravity (second derivative) • rotational inertia (second derivative)

Specialized Calculus Labs and Formative Assessment

- Rare opportunity in the undergraduate curriculum to arrange students' activity and assess this activity at the level evaluate
- Dramatically increases motivation to study calculus, especially for life science majors.
- Addresses "motive, means, opportunity" requirements
- Provides opportunity to assess by observing and partially by interviewing

Formative Assessment– Challenges and Questions

- What data to collect [Ginsburg, 2009]

Performance - overt mastering,

Thinking/Knowledge – Cognitive process underlies the performance,
“why”

Learning potential - Is a student ready to learn the material in question

Affect/motivation – *usually not assessed, we observe in Lab Performance*

- When/ how often to collect data for formative assessment

- Immediately after learning takes place; [e.g. Dihoff et.al.,2003]

- Adjustment of students’ activities to address shortcomings in a timely manner

“... methods of assessment should be based on psychological ideas The theory should make sense to teacher ... It need not deal with broad generalities, like constructivism. ...”[Ginsburg, 2009]

Social Constructivism

- Piaget: “reflective abstraction is a means by which students construct abstract structures as a result of a student reflecting on his/her own **activities** and the arguments used in social interaction
- Instructors have to adapt to the role of facilitators and not teachers. ..facilitator helps the learner to get to students’ own understanding of the content. (Bauersfeld, 1995).

Stage by Stage Development of Mental Actions (SSDMA)

- Instruction (or teaching) is viewed as organizing guidance and assessment of students' **activities** aimed at development of mental actions with objects in the studied field .

SSDMA: Actions & Operations

- Action is a composition of operations
- Different groups of operations perform different functions:
orientation, execution, control/assessment/feedback
- There are three different forms of action:
material form, speech form & mental form
- There are three independent characteristics of action in any form:
degree of generalization, degree of completeness and degree of assimilation
- There are five stages of action development/instruction
- All actions fall into two groups:
specific actions and general logic actions

Minor Things Make Big Difference

- Clear explanation of all activities
- Detailed instruction how to access classroom materials
- Detailed instruction how to submit assignments
- Detailed instruction when to submit, including day and deadline time
- How to receive feedback
- Detailed instruction how to name documents and files
- How to communicate with team mates
- Answering questions, what if...
 - I get sick
 - my dog eats my assignment 😊
 - Team leader does not perform his/her duty

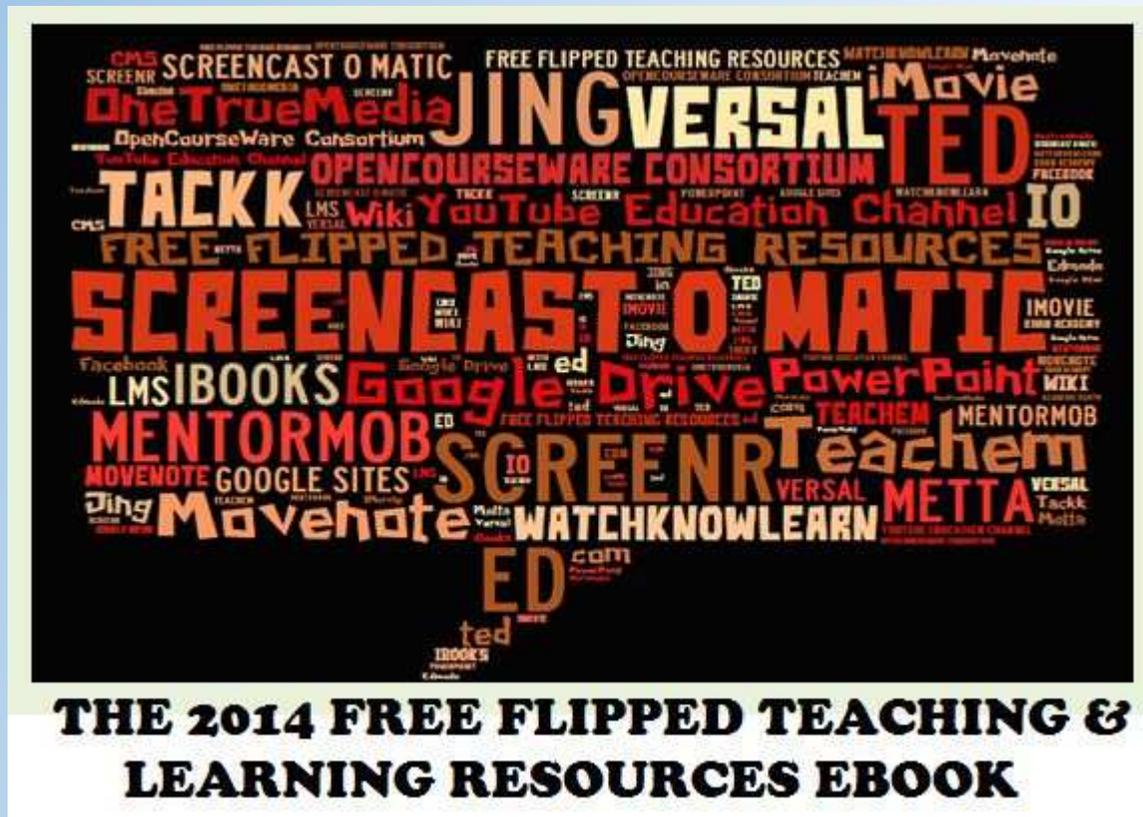
Students Perception of Flipped Classroom

Michener, Patricia L.; Crawford, Pat. Active Learning in Higher Education: *The Journal of the Institute for Learning and Teaching*, v8 n1 p9-30 2007. Quotes from the abstract below.

- “The study found that students valued lectures and being active.
- From the students' perspective, however, working with others (cooperative learning) diminishes the value significantly”

Personal experience

Thank you!!!



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