Developmental Mathematics: Is There a Way Forward?

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A vanguard of math instructors is embracing ideas developed by two Stanford professors to reform math instruction. Their approach includes more visual and creative exercises, discussions of ideas and procedures rather than a focus on memorization and speed, and individually tailored lessons.

San Jose Mercury News, March 18, 2015

Crazy for Calculus

DKDC

Outline

- Developmental Mathematics Revision
- Interesting Research
- Classroom Culture
- Student Risk Factors &

  Faculty Practices, Values, Attitudes
- Learning as a Performance
- Integrating What We Know
- Responses

Developmental Mathematics Revisions

- Curriculum
  - Real World Problems, Project-based, Reduced
- Delivery Method
  - Accelerated
  - Modularized (decelerated)
  - Computerized
  - Supplemental Instruction
- Basic Skills
  - Come to class, on time, pay attention, take notes, do your homework

Modest Successes

- Modest success is good
- MathAMATYC Educator – February 2015
  - College Algebra Redesign (10% increase)
  - Computer-Based Instruction (no difference)
  - Supplemental Instruction (no difference)
- MDRC report (little or no improvement)
- LaGuardia CC (substantial improvement)
  - $14,000 per student

Interesting Research

- Carol Dweck on Mindset
  - Growth vs Fixed Mindset
- Jo Boaler on Brain Malleability
- James Stigler on Culture
  - Productive struggle
  - Explicit connections
  - Deliberate practice
- Learning as a Process
- Learning as a Performance (Theory of Performance)

Changing Education

- The Usual Suspects
  - Active Learning
  - Student Centered
  - Technology
    - Presentation software
    - Graded homework software
    - Testing software (placement and grading)
    - Mathematical software (calculators and computers)

Student Risk Factors

- Risk factors are issues, characteristics or circumstances that may cause students to dropout or fail academically

What We Can Do to Help Students

- Student Risk Factors Related to 4 Areas
  - Perseverance
  - Academic Mindset
  - Learning Strategies
  - Social Skills
- 20 Critical Risk Factor
  - Other risk factors exist

Perseverance

- Lacks self-discipline
- Procrastinates
- Irresponsible
- Afraid of failure
- No sense of self-efficacy
- Financial/Time Constraints

Academic Mindset

- Unmotivated
- Aimless (No clear direction/goals)
- 1st Generation College Student
- Fixed mindset

Learning Strategies

- Teacher pleaser
- Unchallenged (bored)
- Memorizes instead of thinking
- Does not transfer/generalize knowledge
- Highly judgmental/negative about themselves
- Minimal metacognitive awareness

Social Skills

- Non-team player
- Insecure public speaker
- Lacks a support system
- Lacks mentors/Role models

Things to Consider Not Doing

Dimensions of a Culture of Success

1. Challenge
2. Cognitive Complexity
3. Control
4. Delivery
5. Design
6. Efficacy
7. Feedback
8. Measurement
9. Ownership
10. Relationship
11. Self-Awareness
12. Scope of Learning
13. Social Orientation
14. Transparency

Analysis of the Traditional Culture of Teaching/Learning using the Transformation of Education

Aspect	*Descriptor and Focus*	*Faculty Mindset*	*Common Values, Attitudes, and Practices*	*Student Mindset*	*Risk Factor Elevated*
Complexity	Memorizing - *Present a large body of information*	"I have all this required content that I must cover during this course for future courses"	• Content rich courses have over 100 learning objectives /competencies that must be covered • Multiple choice exams are the most efficient means to measure learning with large sections or with extensive information • Must limit the number of challenging or complex questions due to lack of time	"I must memorize all of this information so that I recall it for the quizzes, exams, assignments, and essays."	Memorizers
Complexity	Memorizing - *Practice lots of problems*	"If I challenge learners to really understand at higher levels (problem solving), they would fail the class"	• Teachers test in areas where students have had lots of homework and practice solving problems • Teachers provide a couple of challenging test problems to identify the "A" students • Teachers limit class time to work on open-ended problems because too much content	"It is unfair to put problems on tests that were not presented in class, on homework assignments, or covered in review sessions"	Unchallenged
Control	Teacher Centered - *Exert Authority*	"I know what I want students to learn and I exert my will on them in that direction"	• Teachers will not change dates for exams or provide make up exams in any situation • Teachers decide what is important to learn and when and how it will be graded • Teachers make decisions in the class because they know best what will help the students	"Since faculty have all the control and demand respect, just give them exactly what they want in the way they want it"	Deferential
Control	Teacher Centered - *Defines the rules*	"I want students to follow my rules and do what I ask so they will be successful"	• Teachers define what it means to attend class and participate • Teachers want to see work products done in a specific way (format) • Teachers will have a set of class conventions that must be followed else there will be consequences	"I don't really care what happens with my grade if I can't do what I want to do or do in the way I want to do it."	Irresponsible

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Delivery	Presentation - *share expertise*	"I share my extensive disciplinary expertise with the students"	• Teachers tell students what they will teach them, teach them, and tell them what they have been taught • Teachers explain complex ideas so students can understand them • Teachers create PowerPoint slides as a key resource for the students during class and for review later when studying	"I must capture all of this information because this is what will be on the test"	Transcribers
Design	Rigid - *teach to the test*	"I will provide all examples of how to do the types of problems before they take the exams."	• Teachers provide sample exam problems in lecture and review sessions that closely match the exam problems • Teachers assign a lot of practice problems for homework • Teachers and colleges find it unfair to have students try to solve exam problems in a new context	"I need to remember exactly how to solve each of the types of problems shown and practiced"	Lack of transferability
Feedback	Evaluation - *of people*	"I must constantly point out where students are weak so they can get better"	• Mark up homework and quizzes to show students' deficiencies that need work • Place comments on essays of what needs to be fixed in their thinking and communication skills • Grade down based on mistakes, errors, and missing the point on exams	"I constantly worry about how well I have done, what teachers think of me, if am I doing good, and should I be worried about the future"	Self-evaluators
Self-Awareness	In the moment – doing	"As I can get the student to work harder, I can make them more successful."	• Faculty assigns lots of homework practice problems • Having students write lots of academic papers to illustrate knowledge • Faculty takes attendance	"If I go to class, do the homework, and give the faculty what they want on papers and tests, I will get my degree."	Aimless

Learning as a Performance

- Theory of Performance
  - Identity
  - Skills ←
  - Knowledge
  - Contexts
  - Personal factors
  - Fixed factors

15 Mathematical Learning Skills

- Recognizing patterns – perceiving consistent repetitive occurrences
- Using prior knowledge – integrating unprompted knowledge
- Validating – using alternative methods to test results
- Recalling – retrieving from memory
- Transferring – using ideas in a new context

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Learning Skills for Mathematics

- Analogizing – representing similar elements in dissimilar contexts
- Generalizing – transferring knowledge to multiple contexts
- Quantifying – representing with nos. or eqns.
- Diagramming – clarifying relationships through visual representation
- Recognizing the problem – stating what is wrong or missing

Learning Skills for Mathematics

- Defining the problem – articulating a problem and need for solution
- Establishing requirements – articulating solution criteria
- Subdividing – separating into sub-problems
- Generalizing solutions – modifying solutions for broader applicability
- Analyzing – *(characterizing individual parts)* Identifying similarities, Identifying differences, Identifying assumptions, Inquiring, Exploring context

Aspects of a Culture of Success

1. Challenge
2. Cognitive Complexity
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5. Design
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Transforming Developmental Mathematics

Top Ten Changes

Traditional	Aspect	Education as a Process
In a typical college classroom		In an Education as Process Classroom
Students come in with little preparation and instructors explain or present concepts from the textbook using carefully crafted lectures which some students write notes and try to memorize	**Delivery**	Students read the textbook carefully (creating a glossary and reading log) before class and participate in active learning during class
Instructors model application of concepts at the board to the whole class	**Delivery**	Students demonstrate their understanding of problems at the blackboard in teams
Instructors ask a few questions to the whole class during the lecture which are answered by a few students with students writing down answers	**Cognitive Complexity**	Students working in cooperative learning teams answer critical thinking questions constructing meaning and understanding
Instructor reviews the homework by working the harder problems from the homework in front of the whole class	**Cognitive Complexity**	Students clarify their understanding by validating their solutions
Instructors assign numerous problems from the textbook or homework software	**Feedback/Homework**	Students do at most four problems so they can generalize their knowledge to solve the hardest problem

Review sessions are run by the instructor walking through questions presented by individual students	**Feedback**	Students take well-designed practice tests to assess their readiness and in teams review remaining issues
The evaluation of student performance includes giving students partial credit for incomplete solutions	**Measurement**	Students must validate their own answers to earn any credit for a given solution
Instructors work problems pointing out problems that present important issues	**Social Orientation**	Students work in teams to resolve problems when completing an activity and present important issues and their resolution to the whole class
Minimal learning community and extensive individual work in a very evaluation culture	**Social Orientation**	Students collaborate in a learning community and learning teams with mutual support and assessment
The culture is highly judgmental with faculty focusing on what is wrong, leaving students on their own trying to figure out how to do better with faculty simply suggesting they work harder	**Feedback**	The culture is focused on improvements and students are given the tools and feedback they need to analyze and raise their level of performance in learning math

Integrating What We Know

- What kinds of curricula?
- What experiences do students need?
  - Boot camp: Learning How to Learn Mathematics
  - Learning How to Learn Mathematics courses
- What experiences do instructors need?
  - Faculty members
  - Adjunct faculty members
  - Graduate Teaching Assistants
- What campus-wide support is needed?

Responses

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