

Discussing Mathematical Creativity at the Undergraduate Level

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Motivation

“In seeking to facilitate the development of talented young mathematicians, **neglecting** to recognize **creativity may drive** the creatively **talented underground or**, worse yet, cause them to **give up** the study of **mathematics** altogether” (Mann, 2005, p. 239).




Literature

- Over 100 definitions of creativity in mathematics (Mann, 2005)
- Mathematicians discussed creativity (Hadamard, 1945; Poincare, 1946; Borwein, Liljedahl, & Zhai, 2014)
- Sriraman (2005) K-12 Creativity vs. Mathematicians' Creativity
- Zazkis and Holton (2009) discussed creativity in undergraduate mathematics, posing problems in many different content areas

Creativity-in-Progress Rubric on Proving “CPR”

- **Making Connections:** *The ability to connect the proving task with definitions, theorems, multiple representations, and examples from the current course that a student is in, and possible prior experiences from previous courses.*
- **Taking Risks:** *The ability to actively attempt a proof, demonstrate flexibility in using multiple approaches or techniques, posing questions about reasoning within the attempts, and evaluating those attempts.*

Making Connections

MAKING CONNECTIONS:	Beginning	Developing	Advancing
Between Definitions/Theorems	Recognizes some relevant definitions/theorems from the course or textbook with no attempts to connect them in their proving	Recognizes some relevant definitions/theorems from the course and attempts to connect them in their proving	Implements definitions/theorems from the course and/or other resources outside the course in their proving
			
Between Representations ¹	Provides a representation with no attempts to connect it to another representation	Recognizes connections between representations	Uses connections between different representations
			
Between Examples	Generates one or two specific examples with no attempt to connect them	Recognizes a connection between the generated examples	Uses the key idea synthesized from generating examples
			

Taking Risks

TAKING RISKS:	Beginning	Developing	Advancing
Tools and Tricks ²	Uses a tool or trick that is algorithmic or conventional for the course or the student	Uses a tool or trick that is model-based or partly unconventional ³ for the course or the student	Creates a tool or trick that is unconventional for the course or the student
	➔		
Flexibility ⁴	Begins a proof attempt (or more than one proof attempt), but uses only one approach	Acknowledges and/or uses more than one proving approach, but only draws on one proof technique	Uses more than one proof technique
	➔		
Posing Questions	Recognizes there should be a question asked, but does not pose a question ⁵	Poses questions clarifying a statement of a definition or theorem	Poses questions about reasoning within a proof
	➔		
Evaluation of Proof Attempt	Examines surface-level ⁶ features of a proof attempt	Examines an entire proof attempt for logical or structural flow	Examines and <i>revises</i> an entire proof attempt for logical or structural flow
	➔		

Remarks on CPR

- It is NOT assessing “correctness” or “validity” of the final proof (product).
- It is examining the process of proof production.
- It is NOT a rubric to label student’s creativity.
- It is a formative assessment tool to encourage student’s development of creativity.

Methodology

- Setting
 - Transition-to-proof course in a Liberal Arts University in the West
 - 19 students (12 male, 7 female)
 - Taught using Inquiry-Based Learning pedagogy
 - Every student used a LiveScribe pen for her/his homework and notes
- Methods
 - Voluntary survey for all students after the course
 - Skype interviews with 4 students
 - Interviews fully transcribed

Classroom Environment

- Setting up the environment in the classroom:
 - Pose theorems that have multiple solutions
 - Assign conjecturing tasks for homework
 - Discuss/demonstrate proving attempts
 - Emphasize that mistakes can help
- Use the CPR when students are demonstrating or presenting proofs/reasoning in the classroom

Students' Feedback-1

- It [the rubric] lets me know that, you know, it's okay to go between examples, it's ok to do this, it's ok to do that
- For example, if you have a proof, and you try a direct proof, well **try something different!** Do the contrapositive, or do the contradiction. You know, even if it may not work and in the end you spent an extra 20 or 30 minutes to do it, you know, it pays off in the end and it **builds your creativity.**

Students' Feedback-2

- [W]ell, I would kind of use it as a **checklist** to go through it and when I'm evaluating my proof, I would use and say "could I make any connection?" ...You know, but could I do more? Could I do it better? Could I go from developing to satisfactory in my proof?
- I did try to use it frequently, but for some of them [proofs] you can use them[subcategories]. Like some of them, you can't use all of them. But I did try,... I'm like "ok, **what am I missing?** I'm stuck -- what should I do? I don't know where to go from here", then I would start using this[rubric] and I'm like "ok, so let me get a couple pieces of scratch paper ready, work on it, and do it." And that's what I did. And then I would use this as a checklist.

Students' Feedback-3

- I mean, **thinking about it in different ways** and proving it in different ways is the whole point of being a mathematician, is being able to prove something.
- it [CPR] helped me a lot because when I was studying, and then I would do the problems in the book to help me get more key connections, key ideas-- and then when **I got stuck** on the proof on a problem in the book, I would just look back to this [CPR], and 'oh let me try it this way, let me try it this way.

Thank you!

Questions? Want to use the rubric in your own
classes?

Email us at creativityinproving@gmail.com