

Can we Teach Creativity and Inventive Problem-Solving Skills in Science?

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Guiding Questions

1. What is creativity?
2. Can it be measured?
3. Why is creativity important?
4. How is it related to HOCS?
5. Are there proven teaching strategies for enhancing creativity?

Common definitions of creativity

- ❑ The ability of individuals to generate new ideas that contribute substantially to an intellectual domain (MacKinnon, 1978).
- ❑ The ability to produce work that is novel, high in quality, and appropriate (Sternberg and Williams, 2010).
- ❑ Visualizing a new way to accomplish a task (Craft, 2000).
- ❑ Perceiving a situation or event in two habitually incompatible associative contexts: Bisociation. (Koestler, 1964).

Neurocognitive Analysis:

Executive brain functions

- **Cognitive fluency**: ability to hold and retrieve information; working memory access (Divergent thinking)
- **Cognitive flexibility**: ability to consider multiple ideas and perspectives (Divergent thinking)
- **Cognitive inhibition**: ability to resist several thoughts or actions while focusing on one (Convergent thinking)

Bloom's Cognitive skill levels



From: Anderson and Krathwohl, 2001

Bloom's Taxonomy: Cognitive operations

1. REMEMBERING

naming; listing; recognizing;
locating; recalling facts

2. UNDERSTANDING

interpreting; describing;
summarizing; organizing ideas

3. APPLYING

problem solving; translating
information; using facts or
rules; demonstrating

4. ANALYZING

comparing parts; organizing;
finding underlying structure;
calculating; finding motives;

5. EVALUATING

making decisions; resolving
controversies; judging;
assessing; scoring

6. CREATING

Planning; constructing;
combining ideas; inventing;
conceptualizing; producing

Why Hierarchical?

1. Each level is more complex than the one below
2. Each level depends on a degree of mastery of the ones below

Are HOCS important ?

- 1. I believe that college courses should teach me the facts and major concepts of the subject.**
- 2. I believe that college courses should teach me the facts and major concepts of the subject, and also help me be able to understand, analyze and creatively apply those facts and concepts.**

Critical Thinking Survey*

- ❑ College seniors (114,000 surveyed) who believe that college courses should contribute to their ability to think analytically and creatively: 87%
- ❑ College faculty (20,000 surveyed) who believe that HOCS are an essential indicator of student learning: 93%
- ❑ College seniors who demonstrate proficiency in critical thinking skills: 6%

*AAC&U Student Achievement Report, 2005

Applied Creativity:

Some strategies that work

- **Brain storming without criticism to generate many ideas before focusing or evaluating**
- **Reframe ideas to look at them from different points of view**
- **Generate as many alternative explanations or hypotheses as possible**
- **Consistently reveal and challenge assumptions**
- **SCAMPER: Substitute, Combine, Adapt, Modify, Put to new use, Eliminate, Rearrange**

More strategies for promoting HOCS

- Ranking questions/statements (using HOCS assessment tool)
- 1-minute quiz (most important points?)
- 1-sentence essay (who did what to whom, when, where?)
- Analogic thinking (A is to B as X is to Y)
- Cognitive confusion (analyze muddy logic)

Assessing creative thinking

The fluency/flexibility Game

- ❑ This is an opportunity for you to see how good you are at thinking up new ideas and solving problems. It calls for you to make the best use of your imagination and thinking ability.
- ❑ There are no right or wrong answers; write down everything that comes to mind; try to think of interesting, unusual ideas – ideas that no one else will think of.
- ❑ We also want to find out if between now and later in the course you improve in your abilities to think up new ideas and solve problems, so we'll do another game in a future class.

Unusual Uses of plastic water bottles

Most people throw away their empty plastic water bottles but they could have thousands of unusual uses. List as many interesting and unusual uses you can think of on the sheet you received. Do not limit yourself to any one size of bottle. You may use as many bottles as you like. Do not limit yourself to uses you have seen or heard about; think about as many interesting, clever, and unusual new uses as you can.

Scoring the Game

- ❑ Scoring for *fluency*, *flexibility*, and *originality*.
- ❑ To obtain the *fluency* score, simply count the total number of relevant responses. Each item is worth 1 point.
- ❑ The *flexibility* score is determined from the number of different categories represented in the Flexibility Categories handout. Each category is worth 1 point, but no credit is given for category duplications.
- ❑ There are three levels of *originality*, worth zero, one or two points. These will be defined at the end of the scoring procedure through class discussion.

Flexibility Categories

1. Animal shelter
2. Animal uses, other
3. Art uses
4. Buildings
5. Carrier
6. Construction
7. Container
8. Cooking, Eating
9. Costume
10. Destruction
11. Ecological uses
12. Education
13. Furniture
14. Games
15. Growing
16. Household appliances
17. Music, Noise
18. Pattern
19. Protection
20. Scientific uses
21. Storage
22. Support
23. Tools
24. Toys
25. Transportation
26. Weapons

Further reading

- **Abrami et al., (2008)** Instructional interventions affecting critical thinking skills and dispositions: A stage 1 meta-analysis. *Rev. of Ed. Resrch*, 78(4), 1102-1134.
- **Anderson, et al., (2008)** Gauging the gaps in student problem-solving skills: Assessment of individual and group use of problem-solving strategies using online discussions. *CBE-Life Sci. Ed.*, 7(2), 254-262.
- **DeHaan, R.L. (2009)** Teaching creativity and inventive problem solving in science. *CBE-Life Sci. Ed.*, 8(3), 172-181.
- **Crowe. Et al., (2008)** *Biology in Bloom: implementing Bloom's taxonomy to enhance student learning in biology.* *CBE-Life Sci. Ed.*, 7(2), 368-381.
- **Freeman et al., (2007)** Prescribed active learning increases performance in introductory biology, *CBE-Life Sci. Ed.*, 6(2), 132-139.