

Scientific Creativity in the STEM subjects



Kurt Haim & Wolfgang Aschauer April 2023 Block 1 / Thursday





21st-century skills The 4 C's



Creative problem-solving ability



Biology Chemistry Physics Mathematics Informatics

6 Key Skills for Scientific Creativity



Fostering scientific creativity in STEM subjects



Haim, K., & Aschauer, W. (2022). Fostering Scientific Creativity in the Classroom: The Concept of Flex-Based Learing. *International Journal of Learning, Teaching and Educational Research*, *21*(3).

Learning Tools in flex-based Learning





based

Scientific Creativity in the Classroom

SJÖLINS





Erasmus + APRE©A 🔺 Ma-college = Bildungsdirektion |

CONVERGENT versus DIVERGENT THINKING

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WALLONIE-BRUXELLES



Convergent Thinking



... organizies information.

Water

H,0

neutral

- ... is fact-oriented.
- ... assesses between right or wrong.
- ... searches for the only correct solution.

Acid

HCI

alkaline

Divergent Thinking Paul Guilford (1897 - 1987)



In 1957 Guilford first described creativity as divergent thinking and the ability to generate multiple ideas.

... thinks associatively.

... makes connections.

... allows "both and" answers.

... searches for many solutions.



WHAT IS MORE IMPORTANT?

Convergent thinking

Divergent thinking



Creative performance requires both ways of thinking!

The role of the interplay between convergent & divergent thinking

Creativity is the combination of different fields of knowledge into new patterns.



The more facts I know from diferrent domains,

Recommendations for a successful interplay of convergent & divergent thinking



- Divergent thinking techniques should be incorporated already during the teaching of convergent knowledge.
- Practice divergent thinking through cross-curricular themes.

Divergent thinking for competence orientation



Divergent Thinking Measurability

Fluency

Number of ideas submitted

Flexibility

Originality

Number of categories to whitch the ideas can classified

Surprising ideas that are outside of the expected range.

Divergent Thinking Example of Measurability



White roofs against climate change

To reduce the greenhouse effect, in 2009 U.S. Energy Secretary Steven Chu proposed to paint all roofs white, By reflecting light, less heat would be stored near the ground.



	Number	Causes & Impacts	Categories	
	1	More costs for the homeowner	Homeowner	F
cy = 2				exibili
-luen				ity = 4
				4

Divergent Thinking Which area should be promoted?

Fluency

FLEXIBILITY



The more categories I search, the higher the fluency and the more likely originality.

Originality



Scientific Creativity in the Classroom





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METACOGNITION OF THINKING STYLES

Shorty & Flexy

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Why is being creative so difficult?



Our brain as library



Shorty & Flexy introduce themselves

SHORTY

- ✓ He is convenient and promptly provides you with obvious solutions.
- ✓ He provides routine, so you can make a decision quickly.
- \checkmark His ideas are tried and tested.

FLEXY

- ✓ He gives you creative ideas.
- He needs a little longer time for his ideas.
- He loves to take other points of view. He uses the "perspective check" for this.



multisensory

What ideas do your sensory impressions give you?

PERSPECTIVE CHECK





Imagine yourself in different groups of people or ages.



perspective

Consider the topic at different times.



of plants or animals.



perspective

Change the place or change the point of view.



Critical questioning

What are the possible advantages and disadvantages?



Flexible Search for Reasons

A man comes to a gas station. He reaches for the gas pump and pours fuel over himself. Why does he do this? Find as many reasons as possible!

Now brainstorm allone for 2 minutes about possible reasons and write them down .



Let's reflect on our answers.



Solutions	Flexible Search for Reasons
Count	Reasons
\	
4	



flex based

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GOAL INCREASING FLEXIBILITY IN THINKING STYLES.

PROCEDURE

 Based on a question, as many different answers as possible are to be generated.

oThe task should be considered from many perspectives.



What ideas do your sensory impressions give you?

PERSPECTIVE CHECK



Imagine yourself in different groups of people or ages.



flexbased



Consider the topic at different times.



perspective

Consider the topic from the point of view of plants or animals.



perspective

Change the place or change the point of view.



critically-questioning

What are the possible advantages and disadvantages?

³² Competence Orientation through

Think Flex tasks can be divided into the following types:



Ask questions

Cause of error

Possibilities

Distinctions

Results & Consequences

Advantages & Disadvantages

Uses



>Ask questions

What questions can you think of about a candle flame?

Cause of error The table salt does not dissolve in water - Why?

Possibilities How can the humidity in the laboratory be increased?

Distinctions How can 2 balls of the same size with different masses be distinguished?



Results & Consequences

What would be the consequences of a complete phaseout of fossil fuels?

Advantages and disadvantages What are the advantages and disadvantages of using fireworks?

>Uses

What can you do with a robot that can jump 30 metres high?



https://www.youtube.com/watch?v=daaDuC1kbds

https://www.youtube.com/watch?v=mvHXwTa5-DA

4 Phases in *Think flex* Listen – Think – Pair – Share





1. Capture the problem

- 1. Teacher hands out the worksheet and presents the problem.
- 2. Students should imagine the problem & make a sketch.

Sketching the problem is important to promote Imagination.

Social form: individual work Duration: approx. 3 min.





2. Brainstorming

- Generate many different ideas!
- Work with the help of the perspective check!
- All ideas are written down on the worksheet!

Social form: individual work Duration: approx. 3 minutes





3. Idea exchange

- Students present and discuss their ideas within the group.
- New ideas can and should be further developed by means of group brainstorming!
- Follow the brainstorming rules!

Social form: groups of 2-4 people Duration: approx. 5 minutes



4. Presentation & Discussion

- Students present group results to the class.
- The teacher selects interesting ideas and leads the discussion.
- New ideas can be developed and noted down!
- A collection of ideas including category allocation should be created.
 - Social form:whole classDuration:5-15 minutes



Brainstorming (Alex Osborn, 1953)

The golden rules of creative thinking processes

1. Every idea is allowed. The more spontaneous, the greater the success.

2. Do not make any judgments during the brainstorming process!

3. Taking up already expressed ideas is wishes!

4. The more ideas, the better for the problem solution.

5. Respectful interactions with each other.





Scientific Creativity in the Classroom





Flexperiments

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Flexperiment Flex & *Experiment?*



Methodical

Learning with high mental flexibility!

Practical

Flexible solution-oriented experimentation





GOALS

- Promoting divergent thinking & acting
- ♦ Development of a culture of error
- ♦ Building team competence
- ♦ Increasing self-efficacy in problem solving

What's special about Flexperiments



A simple problem is to be solved experimentally **several times in different ways**.

REASON

- The first solution is obvious and requires only convergent thinking.
- Divergent thinking is required for more solutions.
- As the number of solutions increases, so does originality.



Contents are taught BEFORE the flex experiment!

Competence orientation

Competency is the ability to apply learned knowledge and skills in order to solve problems.





Flexperiment begins with a problem statement

1. Brainstorming Einzeln

2. Austausch & Entscheidung Gruppe





3. Experimentelle Umsetzung Gruppe

4. Präsentation & Reflexion Klasse





> Problem statement should seem trivial.

- Should be relevant and exciting for pupils.
- Should allow for many different solutions.





> Materials are mostly everyday objects

Reason: To encourage misappropriation (critical questioning thinking style).







Available at www.conatex.de

Let's flex

