

Scientific Creativity in the STEM subjects

Kurt Haim & Wolfgang Aschauer

April 2023

Block 2 / Friday



Scientific Creativity in the Classroom

Original Associations

with

CLUSTERING & WoSeCo



Kurt Haim & Wolfgang Aschauer



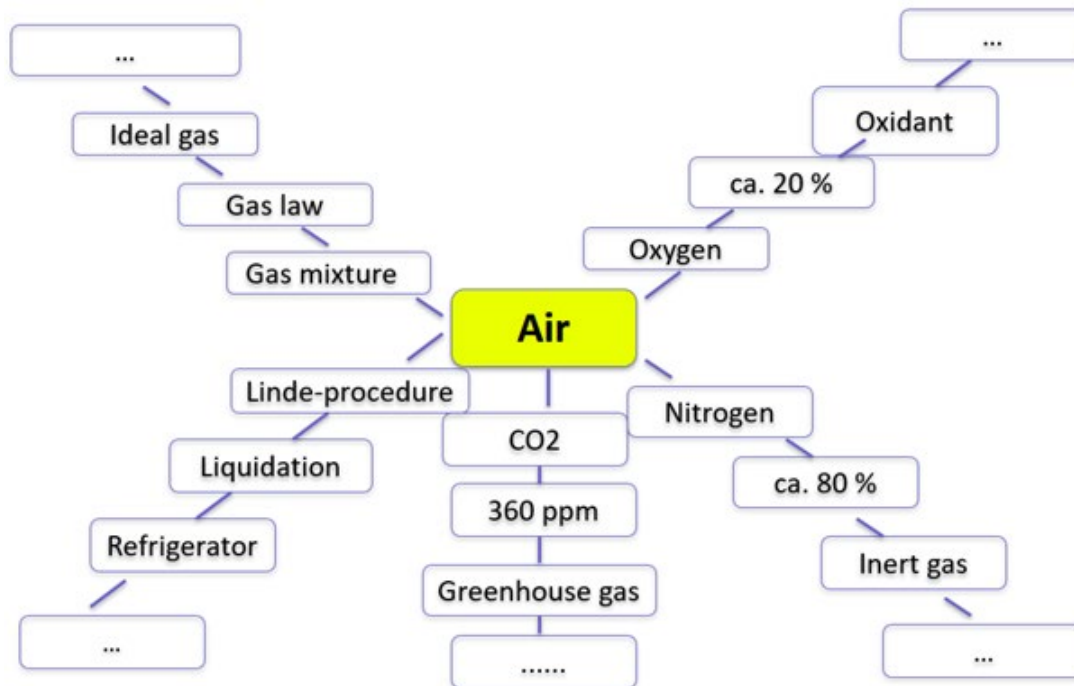
ASSOCIATION is the meaningful linking of terms that originate from a specialized domain.

*Example: **Sulphur** is a **chemical element**.*

ORIGINAL ASSOCIATION is created by combining **distant** terms **within** a subject domain.

*Example: In chemistry, the symbol **S** stands for both the element **Sulphur** and **entropy**.*

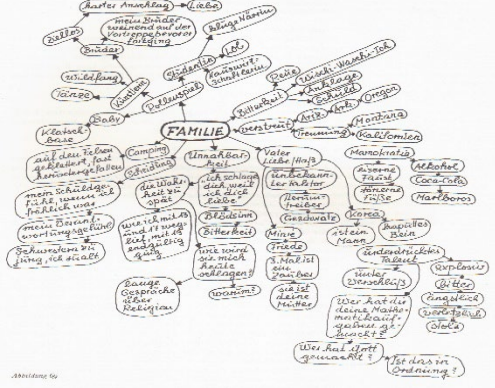
Scientific Creativity in the Classroom



Clustering

Structured
& Stormy

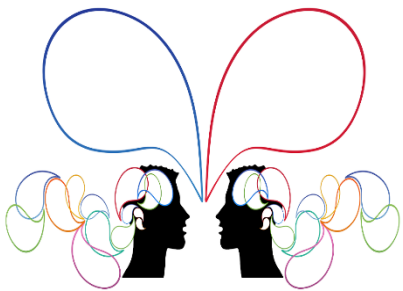
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Clustering

Goals

- Structuring of the material
- Correct interpretation and assignment of technical terms
- Fluency in thinking (see verbal form)
- Preparation for associative ability in WoSeCo



Structured Clustering

Written Form

Task

Students collect all the terms covered in a chapter and record them written down in the form of a cluster.

Theme

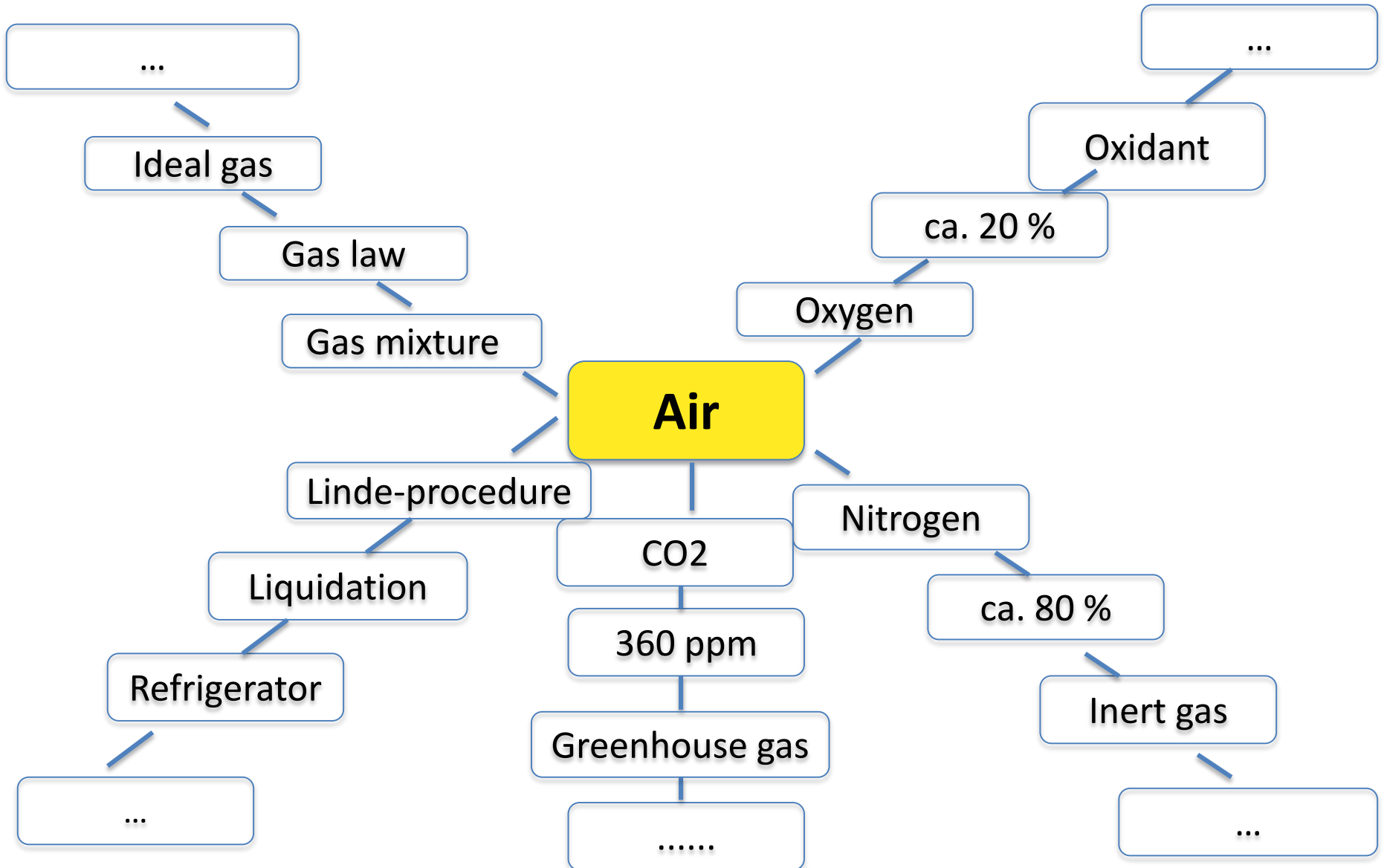
- Within a chapter

Social Form

- Single-Cluster or Team-Cluster

Structured Clustering

Example



Stormy Clustering

Verbal Form

Name as many words as possible for 2 minutes that come to mind intuitively for a certain topic!

Without interruption!



DATA & FACTS

Goal

- Building up a strong semantic network

Requirements

- Technical vocabulary & high concentration

HINT: Verbal form is the basis for effective creativity techniques

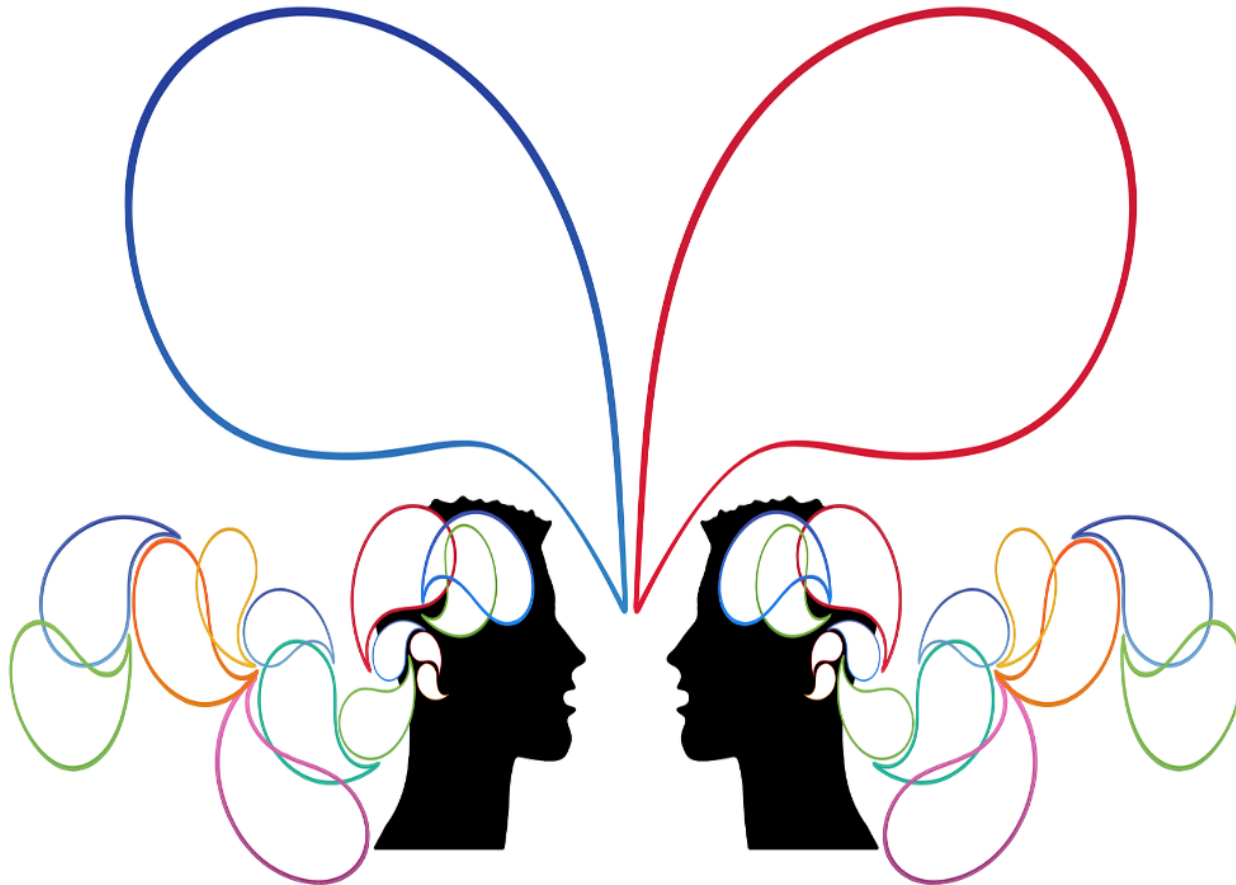
Stormy Clustering

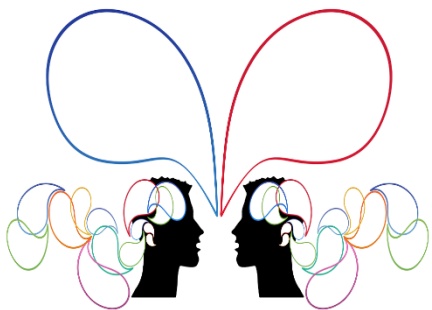
Procedure

1. The teacher sets the topic and limits the verbal clustering to a certain time (e.g. 2 min.)
2. Two students line up opposite each other.
3. One student names as many terms as he/she can think of on the topic in 2 minutes.
4. The counterpart counts all the terms mentioned and provides the cluster creator with feedback on the number and quality of the terms mentioned.

Clustering_Video

Let's do it!





WoSeCo

Word-Sentence-Construction

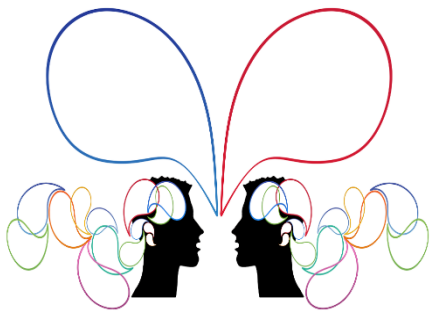
Goal

- Promote original associations by linking terms from different chapters of a domain.

Task

- Two students create scientifically correct sentences from technical terms.





WoSeCo Procedure

1. A sentence with a technical word is given.
2. One student takes the subject word, combines it with a second subject word and forms a meaningful sentence from it.
3. The other person recognises the new technical word and repeats the previous step.

The greater the distance in terms of content,
the more original!

WoSeCo

Example

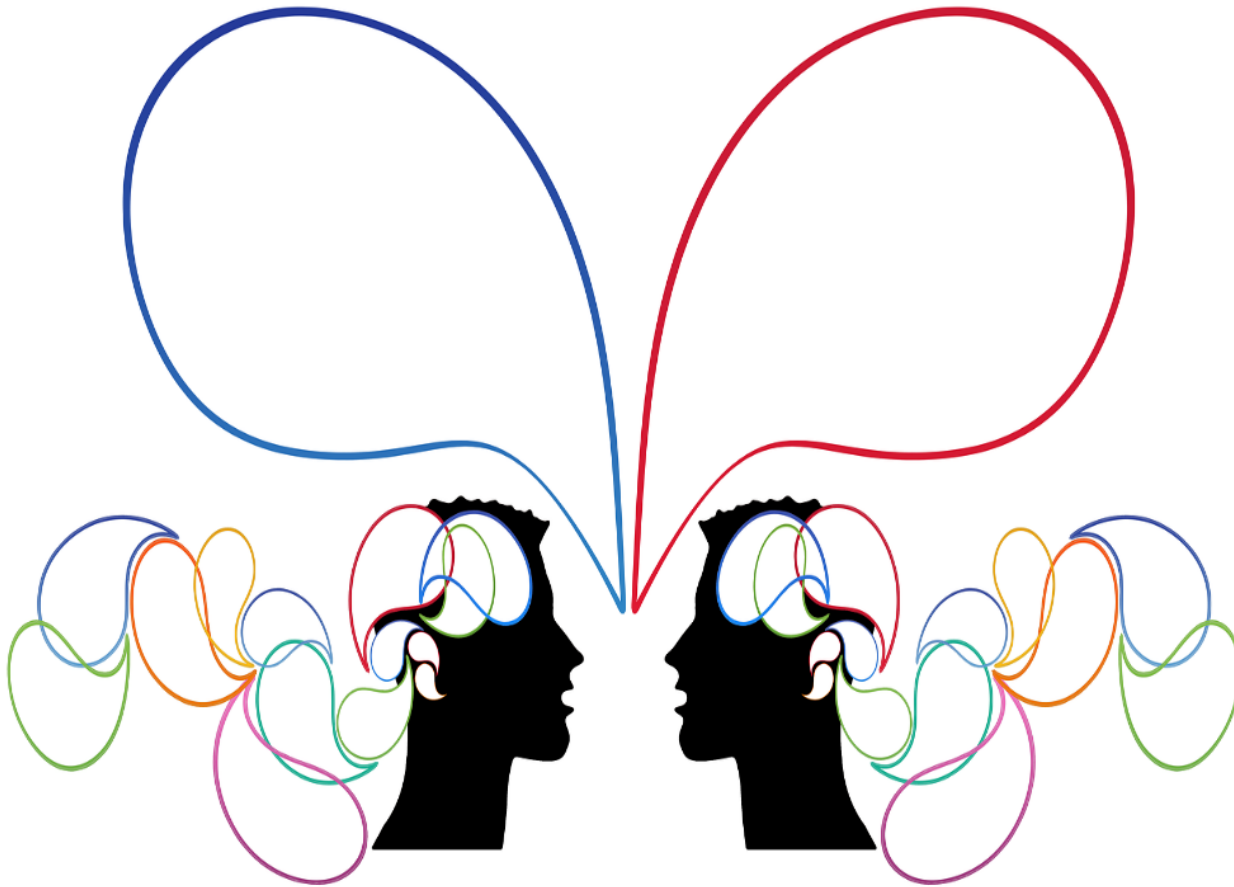
Task: The starting word is **METALS**.

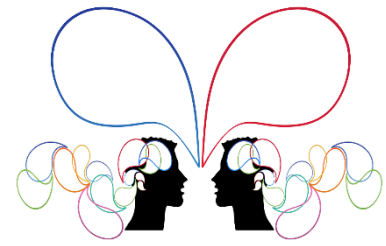
- ✓ Metals are found on the left-hand side of the **periodic table**.
- ✓ The elements are ordered in the periodic table according to the **number of protons**.
- ✓ An element with the proton number 26 is **iron**.
- ✓ Iron can **oxidise** quickly.
- ✓ **Oxygen** is responsible for oxidation.
- ✓ Etc.

Legend: The technical term to be built upon is always underlined and the added technical term is shown in bold.

WoSeCo_Video

Let's do it!





WoSeCo

Variations

Different partners

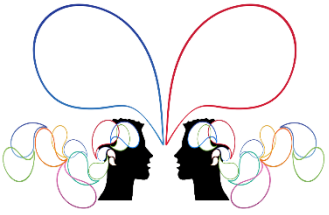
- Single-WoSeCo
- Student-Student-WoSeCo
- Teacher-Student-WoSeCo
- Class-WoSeCo

Theme

- Within a chapter
- Between certain chapters
- Between all chapters
→ Annual WoSeCo

Form of communication

- verbal
- written



WoSeCo

Examples for written implementation

- **Single-WoSeCo in notebook**
- **Double variant in notebook**
- **Double variant with a mobile phone**
- **Class variant on blackboard**



Innovative FOCUS

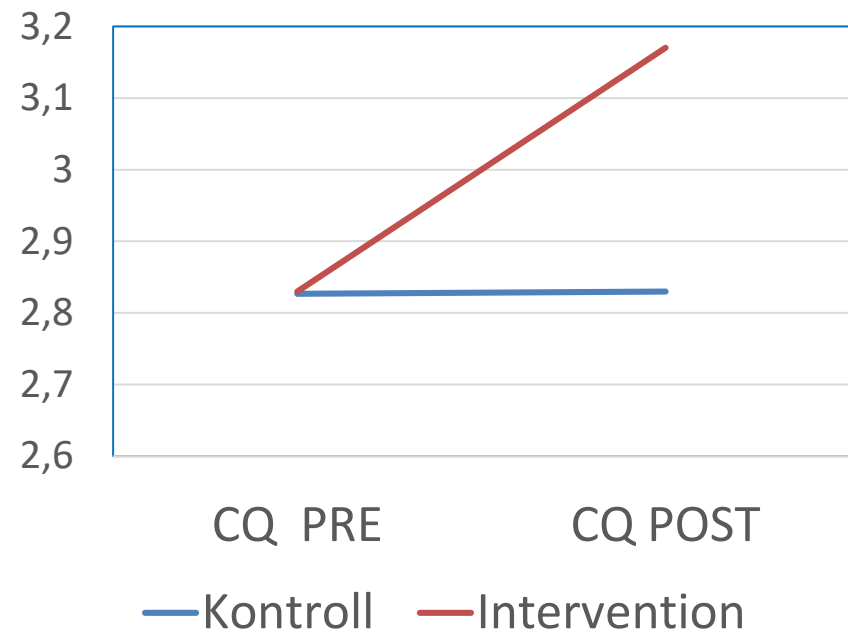
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flexbased Learning



Interventionseffekt



Is divergent thinking = creative problem-solving?



Innovation is a creative idea
in action.

*flex*based
Learning



Creativity in STEM subjects

Innovative
FOCUS



Problem-solving
strategies for real
challenges

INNOVATIVE **FOCUS**

A learning program for innovative problem-solving

F	Flexibility	Flex-based Learning Tools
O	Originality	Creativity Techniques
C	Creative Personality	Metacognition
U	Unconscious Mind	Embodiment
S	Strategies	Project management

CREATIVE⁴FUTURE CHALLENGE



Real problem solving – Design Thinking – Entrepreneurship



SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS



17 PARTNERSHIPS FOR THE GOALS





SCHOOL OF
**CREATIVE
SOLUTIONS**

Our Vision



Youths as problem solvers
and global change makers

Teachers as initiators
for real projects



Schools as think-tanks of
creative solutions

Think Global – Act Local

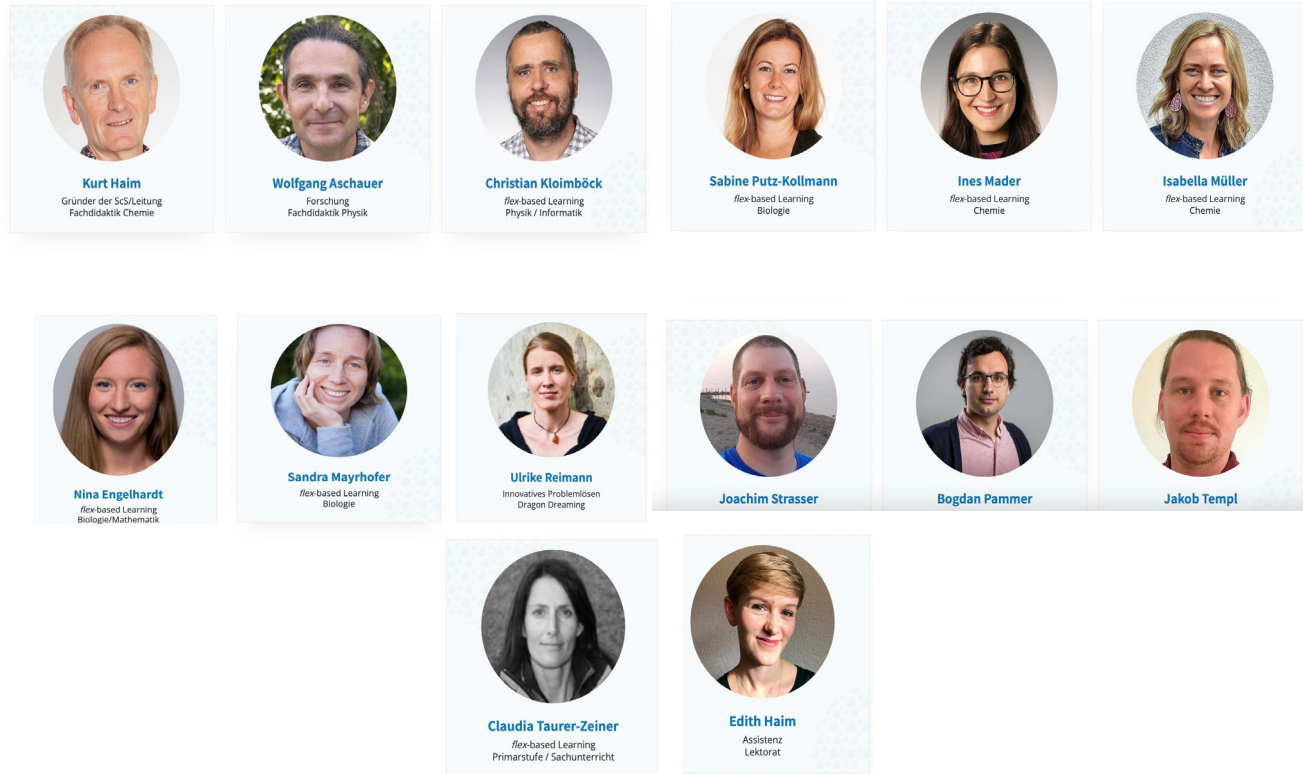


Erasmus

Nepal



The TEAM



Mission statement

Let's empower students to become creative innovators to solve the challenges of today and tomorrow.

Creativity means discovering, experimenting,
growing, taking risks, breaking rules,
making mistakes, and having fun.

Mary Lou Cook



www.school-creative-solutions.at



Innovative FOCUS

APIFOS

Kurt Haim & Wolfgang Aschauer

APIFOS

Analyze Product → Identify Flaws → Offer Solutions

APIFOS helps to uncover weaknesses, that other people overlook.

Application:

Targeted search for improvement

- of a product
- of a service

APIFOS

1. Analyse the Product

The product is examined carefully, analytically and in a non-judgemental way.

The results are noted in a table.

The following questions are helpful:

- *What is its shape?*
- *What material is the object made of?*
- *What properties does the object have?*
- *What is its typical purpose?*

APIFos

2. Identify Flaws

Search for obvious problems as well as hidden weaknesses.

Results are entered into a table.

The following questions are helpful for this:

- What causes problems with the item?
- What can my item actually not do, although it would be useful?
- What would be useful additional functions?

USE THE PERSPECTIVE CHECK

3. Offer Solutions

Some weaknesses are selected from the table and different solutions are offered for them.

NOTES

- The solutions are not yet evaluated according to feasibility.
- The more solutions you can offer, the better.

The innovative fire extinguisher



APIFOS

Analyze Product → Identify Flaws → Offer Solutions

- Analyse the fire extinguisher down to the smallest detail.
- (shape, appearance, function, material, ...)
-
- Write all the details on the worksheet.
 - Time: approx. 5 minutes
 - Form: Individual work



APIFOS

Analyze Product → **Identify Flaws** → Offer Solutions

- 2. Search for hidden weaknesses!
- a. What is not optimal?
- b. What else should the extinguisher be able to do?
- c. What can't the fire extinguisher do yet?
- USE THE PERSPECTIVE CHECK!
- Imagine different fire situations with different people in your mind's eye!
- *Time: approx. 5 minutes / individual work*



APIFOS

Analyze Product → Identify Flaws → **Offer Solutions**

- 1) Exchange the weaknesses you have found in the group.
- 2) Select some weaknesses you want to improve.
 - 3) Look for solutions together in the group!
 - 4) Select the best ideas.
- 5) Sketch an innovative fire extinguisher that is better than the current model.

APIFOS Presentation

- *Present your model to the group!*

- *Time: 3' per group*

- *Discussion*

- *Time: 10'*

Scientific Creativity in Classroom



Be a Comet!



COMET

Personality traits for creatives

Courageous

Open for new things

Mindful

Enduring

Tolerant for failure



COMET Courage

*Being courageous does not
mean not being afraid.*

*It means that you can
overcome your fear.*



Where is COURAGE needed in creative processes?



Expressing unique
ideas



Decision for a risky
choice



Implementation with
uncertain outcome

Young people must be motivated to be
courageous in the phases of creative processes!



COMET

Open for new



*I always do
what I can't do
so that I learn it.*

Pablo Picasso

*Creative personalities are open to **new***
impressions / experiences / findings

Creative personalities are driven by:
curiosity / thirst for knowledge / willingness to experiment



COMET Mindful

**Creative mindfulness means that when solving a
Problem ...**

- ... you observe your surroundings and yourself with high attention
- ...and that you do not immediately evaluate or judge your perceptions



COMET Mindful

Careless people accept the world as it is.

Mindful people realize ...

- *weaknesses of a system*
- *potential of unnoticeable things*



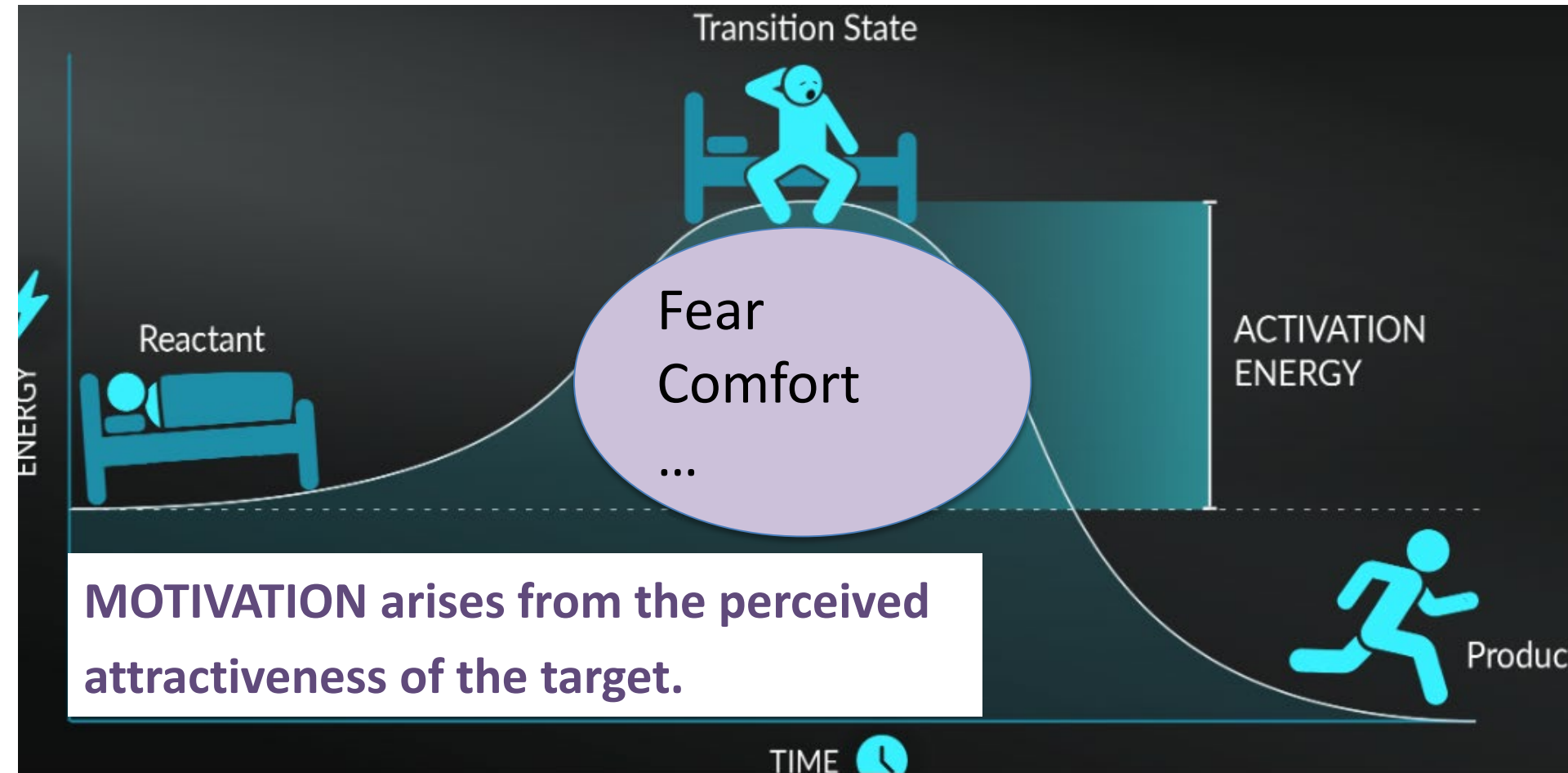
**Mindfulness helps to
recognize blind spots**
(Velcro fastener from Georges de Mestral)





COMET

Endurance





COMET

Tolerant for failure

The things we regret later are not the mistakes we made, but the opportunities that we did not grab.

If you always try to do everything right, you may miss the most beautiful mistake of your life.

Can we really afford mistakes?



COMET

Tolerant for failure

Can we really afford mistakes?

Clear distinction between:

Learning phase
Practice phase

Test
Exam
Application

Productive failure

Manu Kapur



Learning paradox:

Not achieving a desired effect can be just as valuable as mastering it.






Productive failure


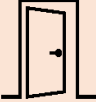








Manu Kapur

3 conditions transform failure into an effective, productive process:

1. Problems must be chosen that challenge but do not frustrate.
2. Learners must have the chance to explain or describe their failed process.
3. Learners must have the opportunity to compare or contrast good and bad solutions.

Personality traits of a creative person

C	Courageous 	<p>Being fearless does not mean <i>not being afraid</i>, but it means that you can overcome your fear.</p>	Be courageous ... <ul style="list-style-type: none"> - to express your original ideas and thoughts. - to try something you have never done before. - to start an experiment when the outcome is uncertain.
	Open for new things 	<p>Openness for new things comes from curiosity and acceptance of the unknown.</p>	Be open ... <ul style="list-style-type: none"> - for unusual ideas from your teammates. - for original ways of solving the problem. - to also work with new colleagues in the team.
M	Mindful 	<p>Creative mindfulness means that when solving a problem, you look at your surroundings and yourself with high attention, and that you do not immediately evaluate or judge your perceptions.</p>	Be mindful ... <ul style="list-style-type: none"> - while you try to understand the problem. - while you are brainstorming for solutions. - while you are trying to implement your ideas.
	Enduring 	<p>Endurance means that you are strong-willed and determined to keep at the problem until it is solved.</p>	Be enduring ... <ul style="list-style-type: none"> - even if unexpected difficulties arise. - even if the first attempt at a solution fails. - even if your teammates want to give up.
T	Tolerant for failure 	<p>This means that you look at a failure as a positive event. Every failure shows you how not to do it and helps you to be better next time.</p>	Be tolerant of failure ... <ul style="list-style-type: none"> - even if you have no ideas. - even if all your attempts to solve the problem failed. - even if the other teams were more successful.

C	O	M	E	T
C OURAGEOUS 	O pen for new things 	M indful 	E nduring 	T olerant for failure 
I was courageous 	I was open 	I was mindful 	I was enduring 	I am tolerant for failure 
in the ... <ul style="list-style-type: none"> ○ Problem analysis ○ Idea generation ○ Implementation 	for new ... <ul style="list-style-type: none"> ○ Ideas ○ Ways ○ Team colleagues 	while ... <ul style="list-style-type: none"> ○ Expressing creative ideas ○ Trying things out ○ Making decisions 	despite ... <ul style="list-style-type: none"> ○ Difficulties ○ Setbacks ○ Resistance in the team 	despite ... <ul style="list-style-type: none"> ○ Lack of ideas ○ Failed attempts ○ Success of other teams
because ...	because ...	because ...	because ...	because ...



SCHOOL OF
**CREATIVE
SOLUTIONS**



Educating Talents

Research Results

flex based
Learning

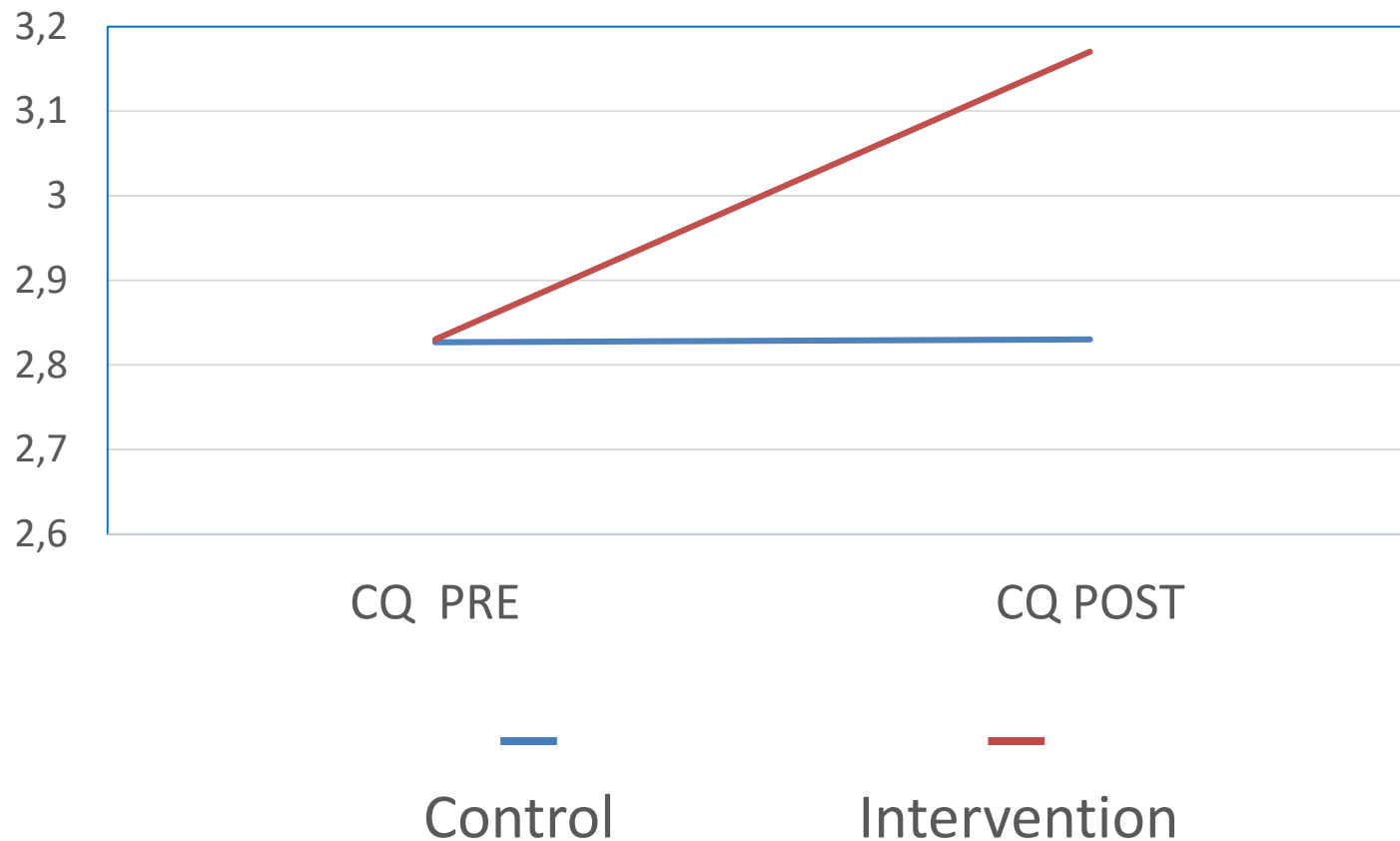


Research

- Sample
More than 3000 students (ages 10 to 18)
Instrument
- Divergent Problem-solving Ability in Science (DPAS) test
(Aschauer, Haim, Weber 2021)
- Methodology
Two-group repeated measures design
Creativity Quotient (CQ) as a composite creativity score
(Snyder et al., 2004)

Research

Efficacy of Intervention (2020 / n= 570)



Research

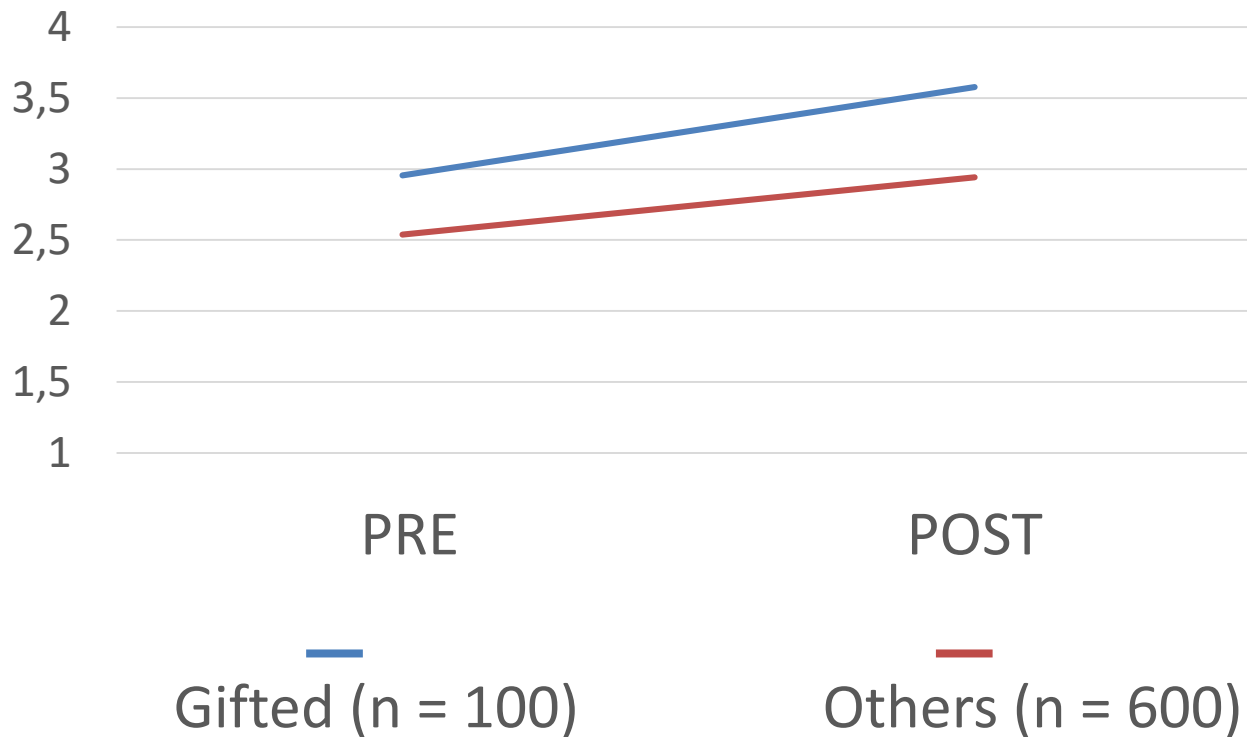
Several authors highlight the urgency of promoting scientific creativity, especially among gifted students (e.g., Heller 2007; Cevher et al. 2014; Kizkapan & Nacaroglu 2021; Karademir 2016; Rule & Olsen, 2016; Stoltz et al. 2015).

Gifted students benefit more than others from special support programs promoting scientific creativity.

Research

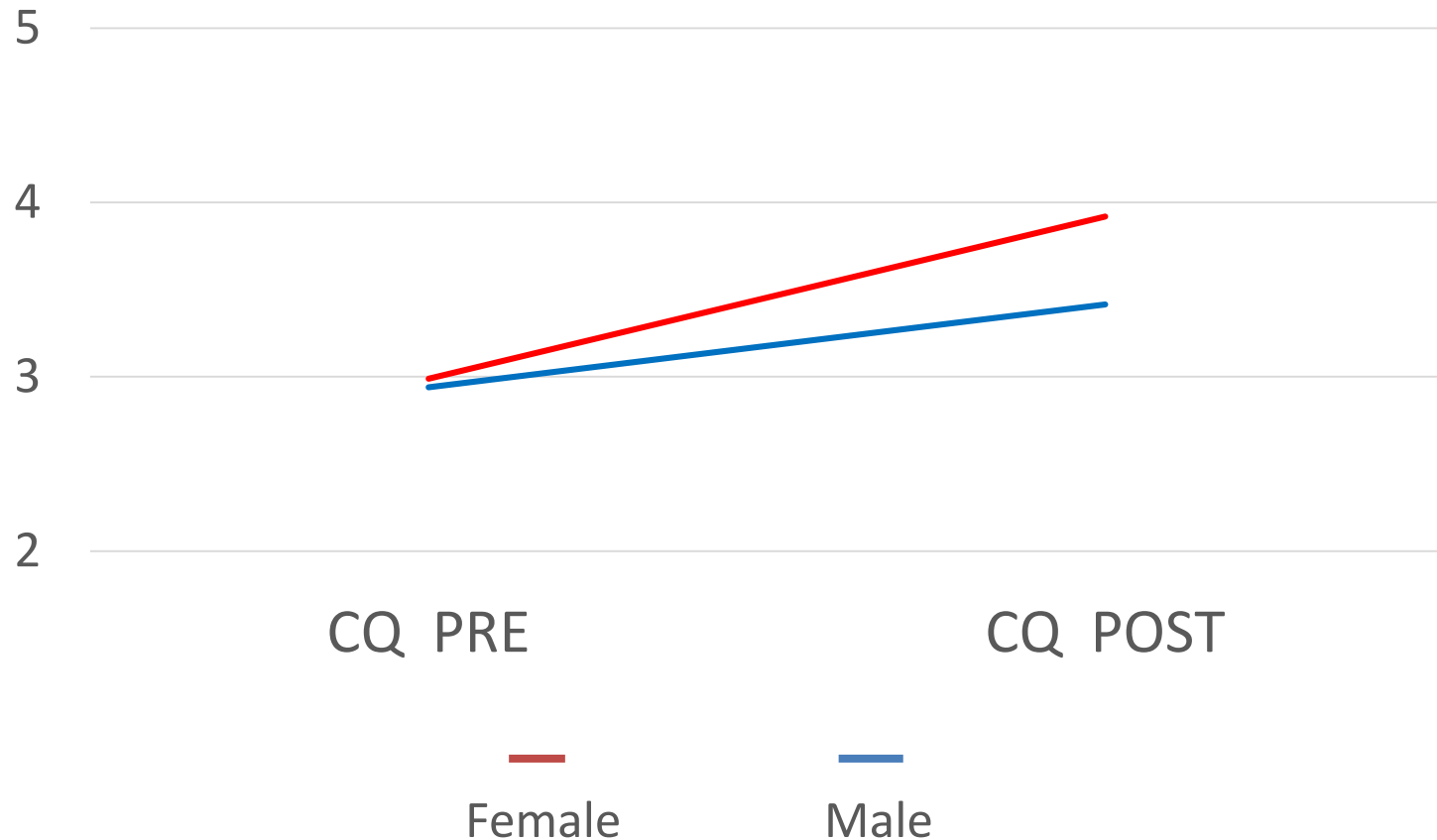
Giftedness Effect within Intervention Group

(2019 / n= 700)



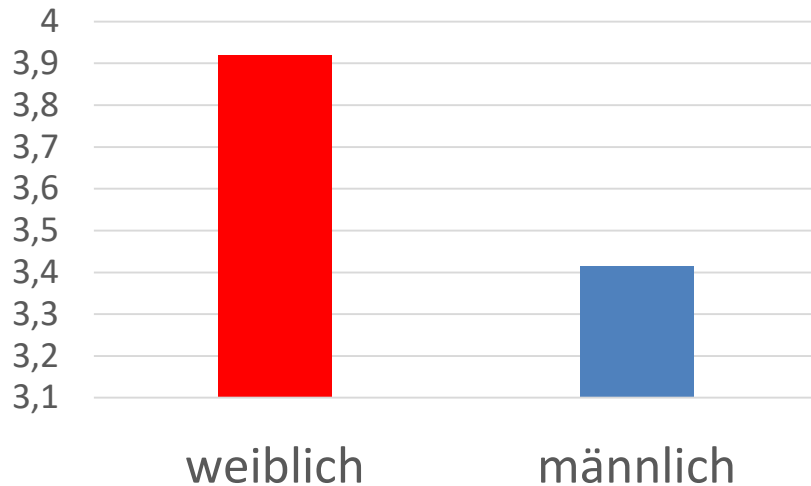
Research

Gender Effect within Gifted

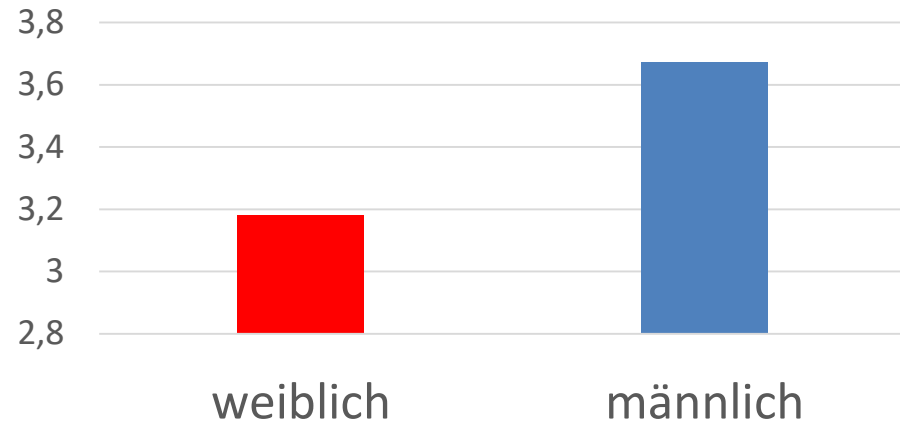


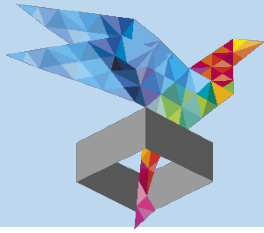
Research

Gender Effect within Gifted
Regarding Creativity (CQ)



Gender Effect within Gifted
Regarding
Self-assessment of Creativity





SCHOOL OF CREATIVE SOLUTIONS

To meet future challenges, young people must learn to solve problems for which there are no ready-made strategies. Let's use the potential of youth and turn school into a place of creative solutions.

THE VISION

a „School of Creative Solutions“ ...

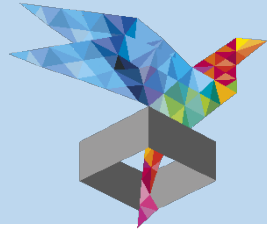
- ✓ educates students who look forward to the future with confidence.
- ✓ has teachers in its ranks who take on current challenges with student teams.
- ✓ is a think tank for innovative solutions and is in exchange with the S.C.S. school network.



OUR GOALS

a „School of Creative Solutions“ ...

- ✓ increases the creative problem-solving skills of young people and teachers.
- ✓ establishes creative spaces for action and solutions in her school.
- ✓ implements innovative ideas in the focus of the Sustainable Development Goals.
- ✓ offers Creative4Science courses for their students.



SCHOOL OF CREATIVE SOLUTIONS

THE S.C.S.-CERTIFICATE

THE WAY

The path to the School of Creative Solutions leads through **2 training modules**:

Module-1: University course
"flex-based Learning"

Module-2: University course
"innovative problem solving"

Both modules can also be attended independently of each other.



CRITERIA

- ✓ Teachers who have completed the flex-based learning and innovative problem solving module teach at the school.
- ✓ Conduct STEM projects with innovative problem solving at regular intervals.
- ✓ Making the projects visible in the school area (school homepage, etc.) as well as on the S.C.S. homepage.
- ✓ The certificate is valid for 3 years and can then be re-applied for.

THE TARGET GROUP

Teachers,

- ✓ ... who teach biology, chemistry, computer science, mathematics or physics at secondary level I and II.
- ✓ ... who want to teach in an innovative and competence-oriented way.
- ✓ ... who want to teach their young people creative problem solving with new teaching techniques.
- ✓ ... who want to carry out exciting and interesting experiments.
- ✓ ... who would like to become part of a nationwide community.



OUR CONTENTS

- Didactic concepts for the diagnosis and promotion of creative problem-solving competence
- Concrete teaching techniques and experiments for science lessons
- Techniques to strengthen team processes and self-efficacy

ORGANISATIONAL

- Course with 9 ECTS in two semesters
- Alternating input and implementation phases
- Presence and online appointments
- Year-round support in implementing the new techniques in their own teaching

REGISTRATION

<https://ph-ooe.at/lehrgang-anmeldung>

01 March 2022 until 18 June 2023

For questions please mail to:

jakob.templ@ph-ooe.at

TIMELINE

Input-Phase 1	Mo. 25.09.23	15:00 – 17:30	Online
	Mo. 02.10.23	15:00 – 17:30	Online
	Mo. 09.10.23	09:30 – 20:30	Presence
	Di. 10.10.23	09:00 – 13:00	Presence
Implementation phase 1 Winter semester 23/24			
1. Team reflection	Mo. 04.12.23	15:00 – 17:30	Online
Input-Phase 2	Mo. 15.01.24	14:30 – 18:00	Online
	Mo. 22.01.24	14:30 – 18:00	Online
	Mo. 29.01.24	09:30 – 20:30	Presence
	Di. 30.01.24	09:30 – 13:00	Presence
Implementation phase 2 Summer semester 24			
2. Team reflection	Mo. 15.04.24	15:00 – 17:30	Online
Degree	Mo. 17.06.24	15:00 – 18:00	Online

DESCRIPTION

The course includes both face-to-face workshops (at the Upper Austrian University of Teacher Education) and online meetings (Zoom).

Input phases

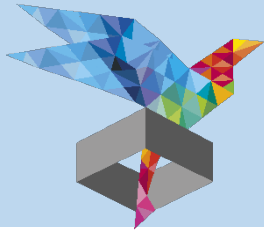
The two input phases take place in autumn and spring. Central elements are:

- ✓ e-lectures with reflection phases (Online)
- ✓ Workshops (presence and online)

Implementation phase

The implementation phases in the winter and summer semesters include the following elements:

- ✓ Use flex-techniques in your own teaching
- ✓ Reflections on the experience gained



University course "Innovative Problem Solving"

School as a think tank for creative solutions

THE TARGET GROUP

Teachers, ...

- ✓ ... of all subjects in lower and upper secondary education as well as middle management
- ✓ ... who are interested in creativity techniques to develop innovative ideas professionally.
- ✓ ... who enjoy taking on STEM challenges at school.
- ✓ ... who want to know how to plan and implement creative projects with young people.
- ✓ ... who are committed to the "Sustainable Development Goals".



OUR CONTENTS

- Creativity techniques
 - Morphological box
 - Irritant word associations
 - Bisociation
 - Passla technique
- Creative project management
 - Design Thinking
 - Dragon Dreaming

ORGANISATIONAL

- Course with 9 ECTS in two semesters
- Presence and online appointments
- Year-round support in implementing the new techniques in their own teaching

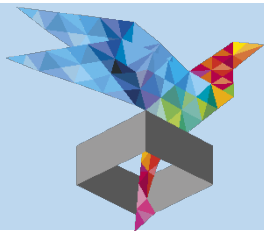
REGISTRATION

<https://ph-ooe.at/lehrgang-anmeldung>

01. März 2022 bis 18. Juni 2023

For questions please mail to:

kurt.haim@ph-ooe.at



University course "Innovative Problem Solving"

School as a think tank for creative solutions

TIMELINE

1. Presence-Phase Health Resort Lebensquell Bad Zell	Do. 21.09.23	09:30 – 21:30
	Fr. 22.09.23	09:00 – 21:30
	Sa. 23.09.23	09:00 – 12:30
Reflection meeting (online)	Do. 19.10.23	14:30 – 17:30
	Do. 30.11.23	14:30 – 17:30
2. Presence-Phase Health Resort Lebensquell Bad Zell	Do. 29.02.24	09:30 – 21:30
	Fr. 01.03.24	09:00 – 21:30
	Sa. 02.03.24	09:00 – 12:30
Reflection meeting (online)	Do. 04.04.24	14:30 – 16:00
	Do. 09.05.24	14:30 – 16:00
Action day at school	April 2024	08:00 – 12:30
Degree (online)	Mo. 17.06.24	16:00 – 18:00

Creative⁴Innovation-Courses

For the implementation of the course content with student teams, we recommend holding a course lasting several weeks.



GEMMMA Challenge

10 selected school teams are introduced to the world of social entrepreneurship and supported in the implementation of their projects.

Milestones

- ✓ Young people learn proven creativity techniques.
- ✓ Student teams choose a project for their problem solving.
- ✓ A prototype is created using design thinking.
- ✓ Presentation of the prototypes
- ✓ Optional implementation of solution ideas in cooperations