# Creative Thinking Activities & Assessments for Use in Any Course to Grow Students' Creativity

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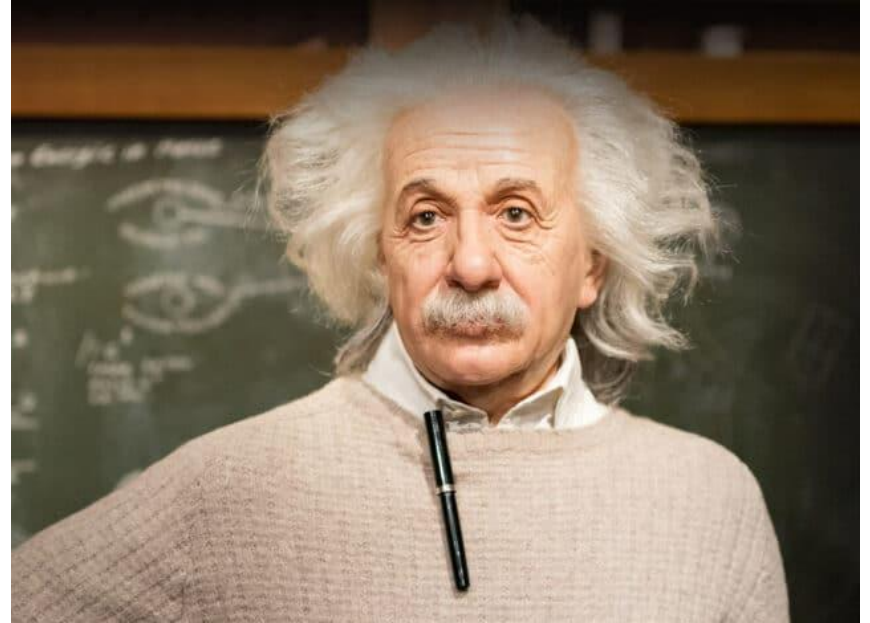
And

Kenny Kuo, PhD
Assistant Teaching Professor of Biochemisty

**"Creativity is MORE important then Knowledge"**
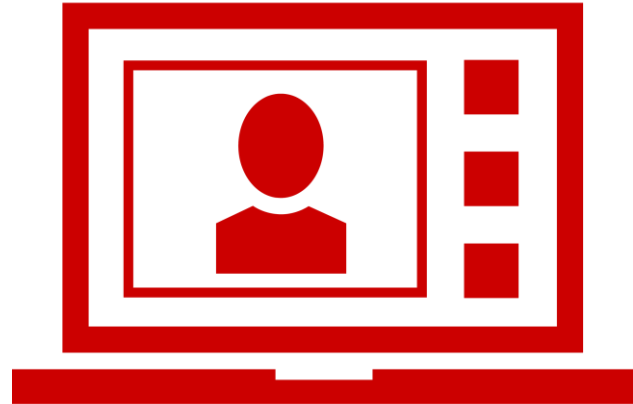
*- Albert Einstein*

# Creativity is Similar to Intelligence in Many Ways
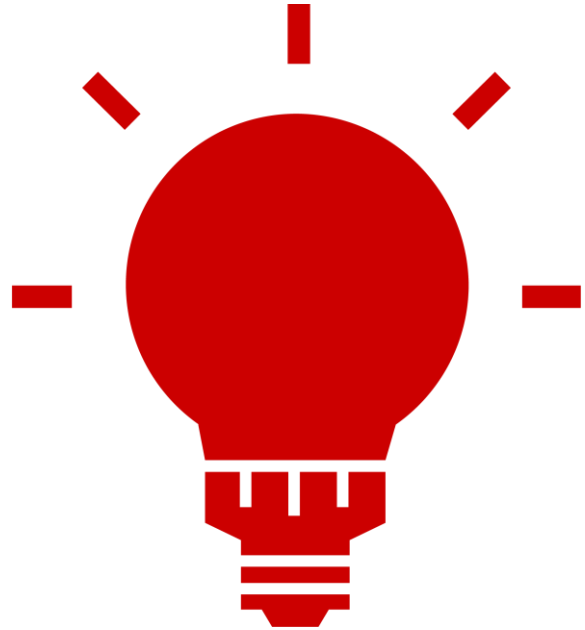## *(Kim et al. 2010)*

- Everyone has some
- It can be developed and nurtured
- There are levels
- It can be expressed in many ways
- It can be viewed as a general ability and as a content specific ability

# Adjectives Associated Creative Thinking
### *(Starko 2021)*

- Novel (*Original)*
- Appropriate ("meets *some goal or criterion*")
- Useful
- Purposeful

# Creative Thinking is

- "the capacity to generate many different kinds of ideas, manipulate ideas in unusual ways and make unconventional connections in order to outline novel possibilities that have the potential to elegantly meet a given purpose" *(Ramalingam et al 2020)*

# Why do all our students need to grow this skill?

- An analysis of millions of online job postings identified creativity as a critical "human skill"
  *(Markow et al. 2018)*

- Considered the most in-demand soft skill for employees
  *(Petrone 2019)*

# Research

- Results from various studies have emphasized that **creative thinking, critical thinking, problem-solving, and decision-making are the skills that students need to develop as the main 21st century competencies**

  *(e.g. see Organization of Educational & Economic Development – OECD 2010; UN Educational, Scientific & Culture Organization - Care & Luo 2016)*

# Relationship of Creative Thinking & Critical Thinking
## *(Muglia Wechsler et al 2018)*

- Critical & Creative Thinking are independent of each other in cognitive performance, even though they are **both complementary to each other**
- Critical thinking found to require <u>strong thinking and reasoning skills</u>
- Creative thinking found to favor <u>inductive reasoning, fluency and originality</u>

# Main Class for
# Creative Thinking Activities

- *Critical & Creative Thinking in the Life Sciences*
- 3 sections of 30 to 50 students in each
- Small tables with groups of 4 students
- Discussion-based, problem-solving, case studies

# Also use in large lecture class

- *Introductory Biology I: Biodiversity, Ecology, & Evolution*

- ~200+ students in auditorium style classroom

- Students work in groups of 4 periodically in class

# For Engagement in the Classroom

1. Identify the goal or objective for the students
2. Think backward design on how to meet that objective
3. Design a creative thinking assessment

# Homework Example:
# From my *Introductory Biology* course

- I want students to learn more about CRISPR technology and applications to society

- I ask them to read a short article and then to translate what they learned into a visual for any person to understand

# Directions to Students

- This article describes the butterfly study using CRISPR to a more general audience. After reading the article, create a diagram or cartoon to illustrate the experimental design described in this article.

- Your illustration can be general but should show how the scientists conducted the overall experiment. You will want it to be visually appealing (so think color and figures) as well as scientifically accurate (think about conveying the main methods and results).

| Visual Appeal | Colorful, pleasing to the eye (4 pts) | Lacking in appeal (e.g. no color, sloppy, no real effort given) (2 pts) |
| --- | --- | --- |
| Accuracy of Conveying Content of Article | Viewer can understand the methods and results from looking at the visual (4 pts) | There are gaps in conveying content (e.g. methods are not clearly conveyed and/or results are not conveyed fully) (2 pts) |
| Overall Effort | Overall sense that time and effort was given to the assignment (2 pts) | Overall sense that effort was minimal based on product (1 pt) |

# Examples of Student Work

# Examples of Student Work



Normal butterfly Genome

*optix*

Orange Pigments Present

CRISPR deletes Optix

Altered butterfly Genome

Orange Pigments Absent

CRISPR has the ability to alter butterfly coloring. Deletion of the *optix* gene removes orange and red pigments in butterfly wings.

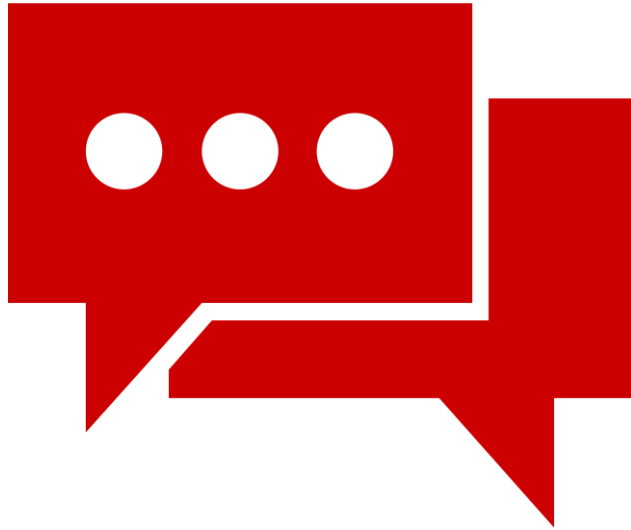# Examples of Student Work

# Starting Point for Class:
## To help get creative thinking "activated"



- Work in class together on something to help students see that **creativity is sparked as they are "doing"**

- Remind students that creative thinking is an active process

# Example in my *Introductory Biology* course

- After going over a topic (e.g. evolution via genetic drift or natural selection) I can show a photo and ask students to create an analogy story to help us remember how genetic drift works
- Let's try together…..

From JetSetter Magazine

# Different Strategies to Use with Students
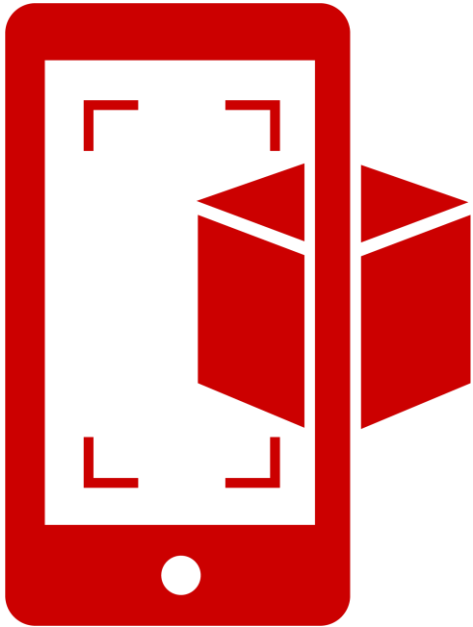


- **Divergent Thinking** Exercise
  - Fluency (number of ideas)
  - Flexibility (categories of ideas)
  - Originality (unique ideas)
  - Elaboration (details to ideas)

# Example of Divergent Thinking

- List as many possibilities as you can imagine in 2 minutes for the following topic:

# Example of Divergent Thinking

- List as many possibilities as you can imagine in 2 minutes for the following topic:
**How to Stay Healthy as You Age**

# Then after this warm-up, ask about something specific to your discipline or course

- Examples
  - How to prevent photosynthesis from happening (to control weedy species)
  - How to attract more customers for your product
  - Reasons why WWII escalated to the levels it did

# Different Strategies to Use with Students

- **Find 10 Questions** Strategy
  - Need to do this quickly based on an observation (give only 2 minutes)
  - Will help with brainstorming for project topics
  - Will help with trying to solve a problem

# Example

- Find 10 questions for the observation:
- The majority of animal species that are endangered or extinct are large animals (like gorillas, leopards, rhinos, elephants).

# **Questions that Might Come:**

- What properties do mammals have that other animals do not?

- What does it mean to be endangered?

- Does becoming endangered always lead to extinction?

- What is it about large size that is disadvantageous to dealing with environmental changes?

- Etc…… *(this should lead to great discussions & relevance of course content)*

# Different Strategies to Use with Students

- **Six Thinking Hats** = View a problem or decision from different perspective than your usual disposition



Managing the Thinking Process

Information

Intuition and Feelings

Benefits and Feasibility

Caution, Risks, Problems

Alternatives and Creative Ideas

- Uses different perspectives based on color
  - White for facts
  - Red for emotion
  - Yellow for benefit
  - Green for ideas
  - Blue for planning
  - Black for judgment

# Example of Six Thinking Hats
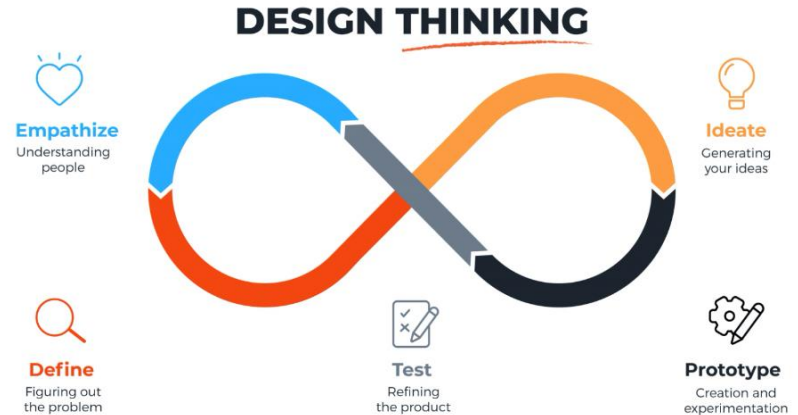## from my *Critical & Creative Thinking* course

- Goal is to practice writing arguments using different rhetorical elements



- **Prompt** = Consider the pros and cons associated with stem cell research.
  - Chose to argue either FOR or AGAINST funding stem cell research.
  - Use two different hats in your argument.
  - Use either ethos, pathos, or logos in the arguments (and identify which you are using)

# Different Strategies to Use with Students

- **Design Thinking** Strategy
  - What do people NEED,
  - what is POSSIBLE with technology &
  - what is REQUIRED for success

# Example of Design Thinking
## in my *Critical & Creative Thinking* course

- You and your team are tasked with recruiting more students into the life sciences majors. How can you successfully target an undecided major who likes science but thinks it is "too hard" a major to pursue?

# Different Strategies to Use with Students

- **SCAMPER** Strategy
  - Substitute
  - Combine
  - Add
  - Modify
  - Put to another use
  - Eliminate
  - Rearrange
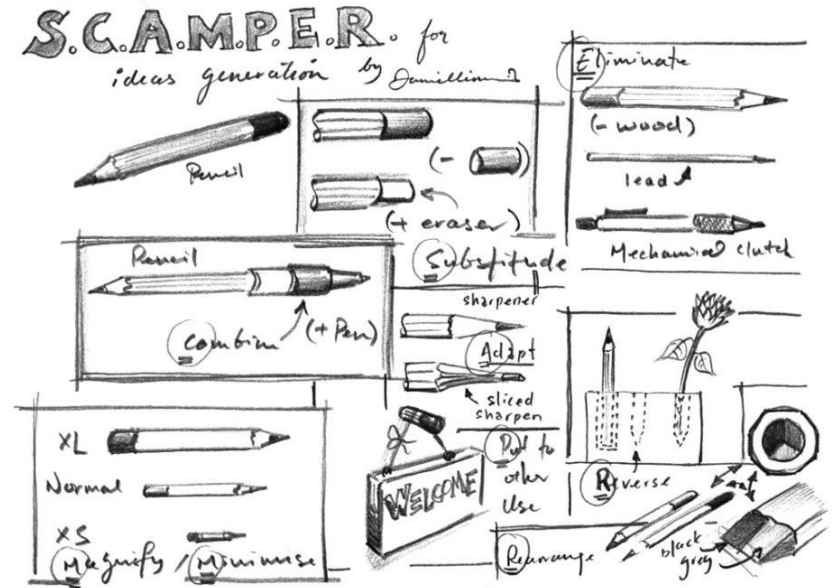
# Different Strategies to Use with Students

- **Key Attribute Listing** Strategy
  - A problem or product is divided into key attributes that are addressed separately
  - Then consider each category/attribute to create a new combination

# Example from my
# *Introductory Biology* course

- Pick one species of animal that lives in the desert (e.g. hare, snake, coyote, camel, scorpion, etc.)

- Write down as many attributes associated with this species (e.g. morphological characters)
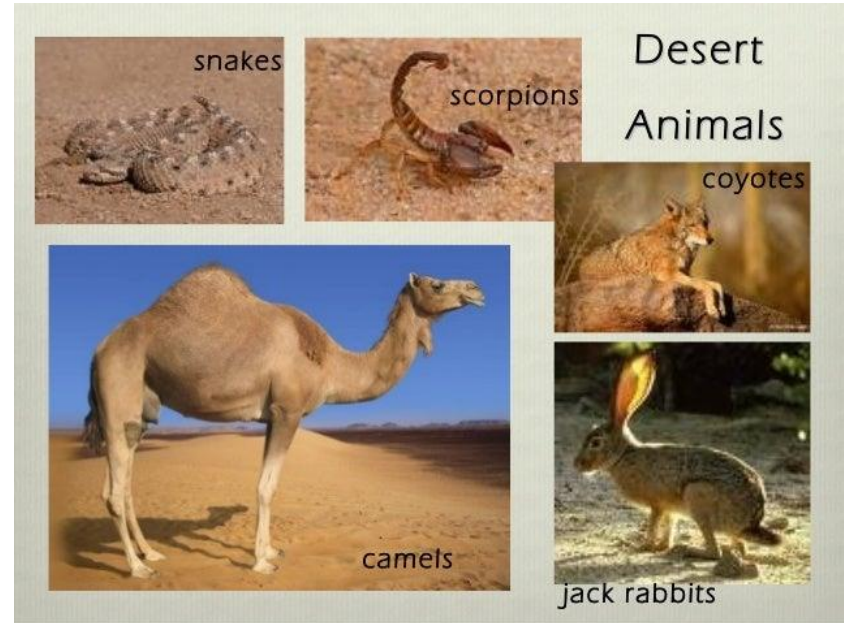
# Example from my
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- Now identify one attribute of the habitat to change (i.e. selective pressure) and list how this will likely affect the population of this animal over time.

  - This can help with understanding natural selection

# Have Students *USE* these Standards



In class to grow their understanding



And reinforce for their own application outside of class

# Example Exercise

Use a total of 100 points to distribute to the 4 intellectual standards as you see fit to create your rubric

Using this rubric, critique an endeavor (or a problem or a set of data or a situation – depending on your discipline and your interests/goals)

# I have used this application

- When critiquing a scientist's series of experiments and logic of moving from A to B based on data collected
- When considering an argument made (written or verbal) by an expert (e.g. COVID restrictions were necessary to curtail the spread of COVID)
- To critique endeavors or products (example on next slide)

# Endeavor

- Because mobility decreases significantly as elderly people age, two scientists have been working to produce a computer chip that could be embedded in the limbs of a person to help coordinate movement of arms and legs.  They haven't been able to get it to work exactly as they would like, but they are consistently tweaking it and improving on the design.

- They hope to have it working efficiently and effectively within 5 years and envision the chips replacing walkers, crutches, and wheelchairs.

# This can lead to a class discussion

- On cell design
- Bioengineering
- Ethics
- Etc.
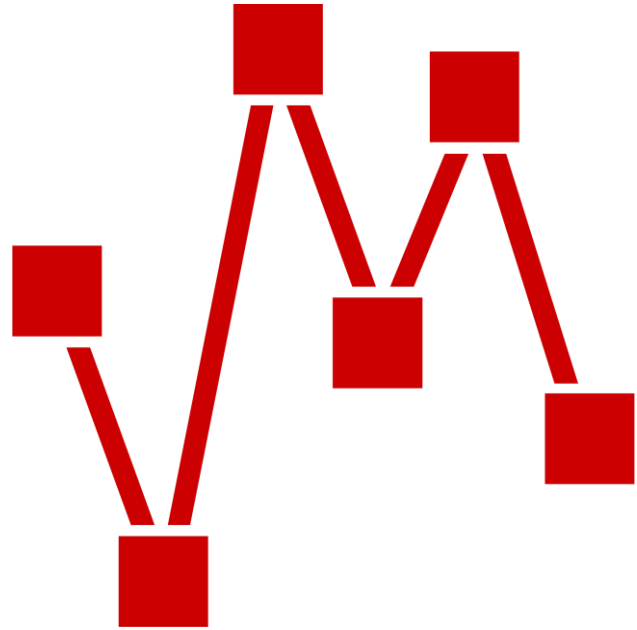
# Different Strategies to Use with Students

- **Mindfulness Practices**
  - Short 5-minute meditations
  - Short breathing exercises
  - Listening to mindfulness bells
  - Listening to famous classical music
  - Focusing on famous artwork for 10-second series and highlight observations

# Can Encourage and/or Assign Work Outside of Class to Grow Creativity

- Assign one of the strategies for a topic of relevance (e.g. SCAMPER or Ask 10 Questions)

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- Encourage mindful "procrastination" – give assignment in parts or give whole assignment and collect & then return and days later ask to do again or in another way

# Encourage a Growth Mindset

Allow students to make mistakes without worry

E.g. retake quiz option

# Do These Activities Actually Help Students?

- TTCT Instrument Used (Torrance Test for Creative Thinking)

- Students took assessments at the start and again at the end of the semester (2 different versions)

- Looking at fluency, flexibility, and originality

# Data from Fall 2021

- 275 students included in the study

- 2 sample t-tests, one-way ANOVA, multi-way ANOVA, and Tukey-Kramer procedures were used

# The TTCT Instrument

- Highly reliable & verified
  - (e.g. see Trisnayanti et al 2019)
- One of the most widely used creativity tests (has been administered since 1966 & translated into 35+ languages)
  - (see Davis 1997)

# TTCT Instrument

- Six sections to the test that are timed
  - need ~45 minutes to complete
- Activities include:
  - Asking questions about an image/scene
  - Guessing causes
  - Guessing consequences
  - Improving a product
  - Developing ideas for unusual uses

# Scoring

The TTCT uses a normalized standard score having a mean of 100 and a standard deviation of 20.

Average Standard Score – an average produced when weighing the separate assessments equally
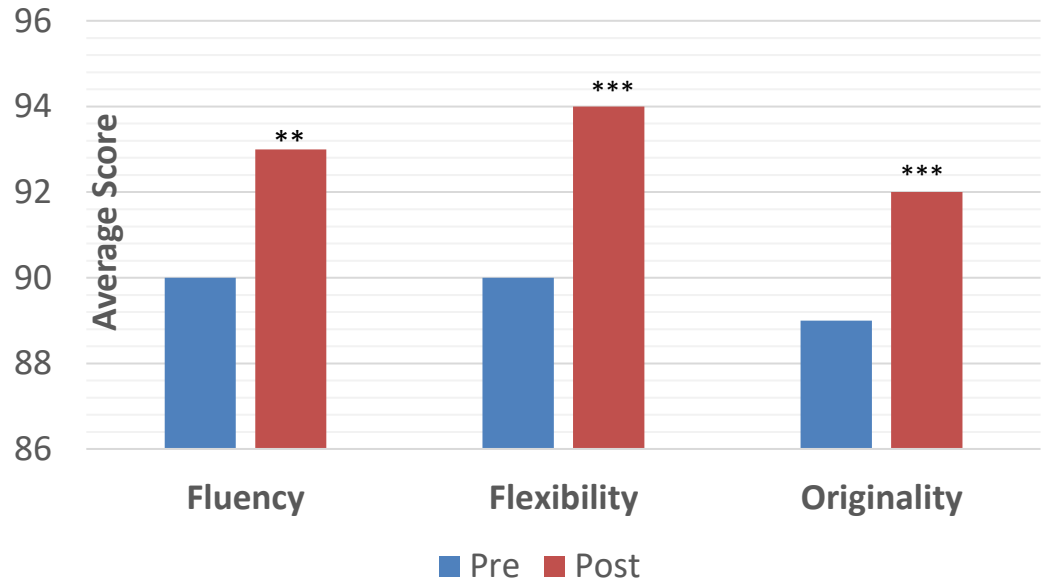
# Results

- 228 students for both pre and post semester

- **Mean Pre-Semester = 90**
- **Mean Post-Semester = 93**

*Fluency (t=2.52)*
*Flexibility (t=2.99)*
*Originality (t=2.73)*

# Results from Pre & Post Semester Scores
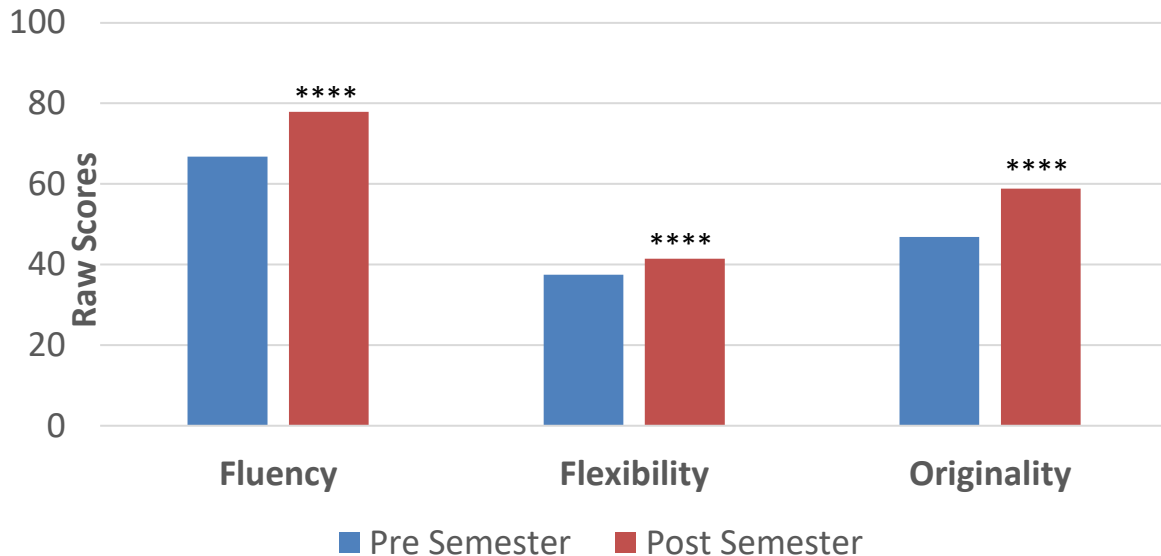
Fluency, p = 0.0013

Flexibility, p = 0.0002

Originality,  p = 0.0008

Average, p = 0.0010

Creative Thinking
was higher at end of the
semester (compared to
the beginning of the
semester)

# Raw Scores

- **Fluency Gain +11.1**
  (t=5.93, p<.00001)

- **Flexibility Gain +3.9**
  (t=4.99, p<.00001)

- **Originality Gain +12**
  (t=7.41, p<.00001)

# Influence of Race

- 6 races self-identified by students: Asian, Black, Hispanic, Indian, Multi-racial, & White
  - Due to some small sample sizes, compared BIPOC students to White students

- No differences were found between students of different races when examining
  - Fluency (pre, t=0.99; post, t=0.63)
  - Flexibility (pre, t=0.18; post, t=0.72)
  - Originality (pre- t = 0.14; post, t=0.33)
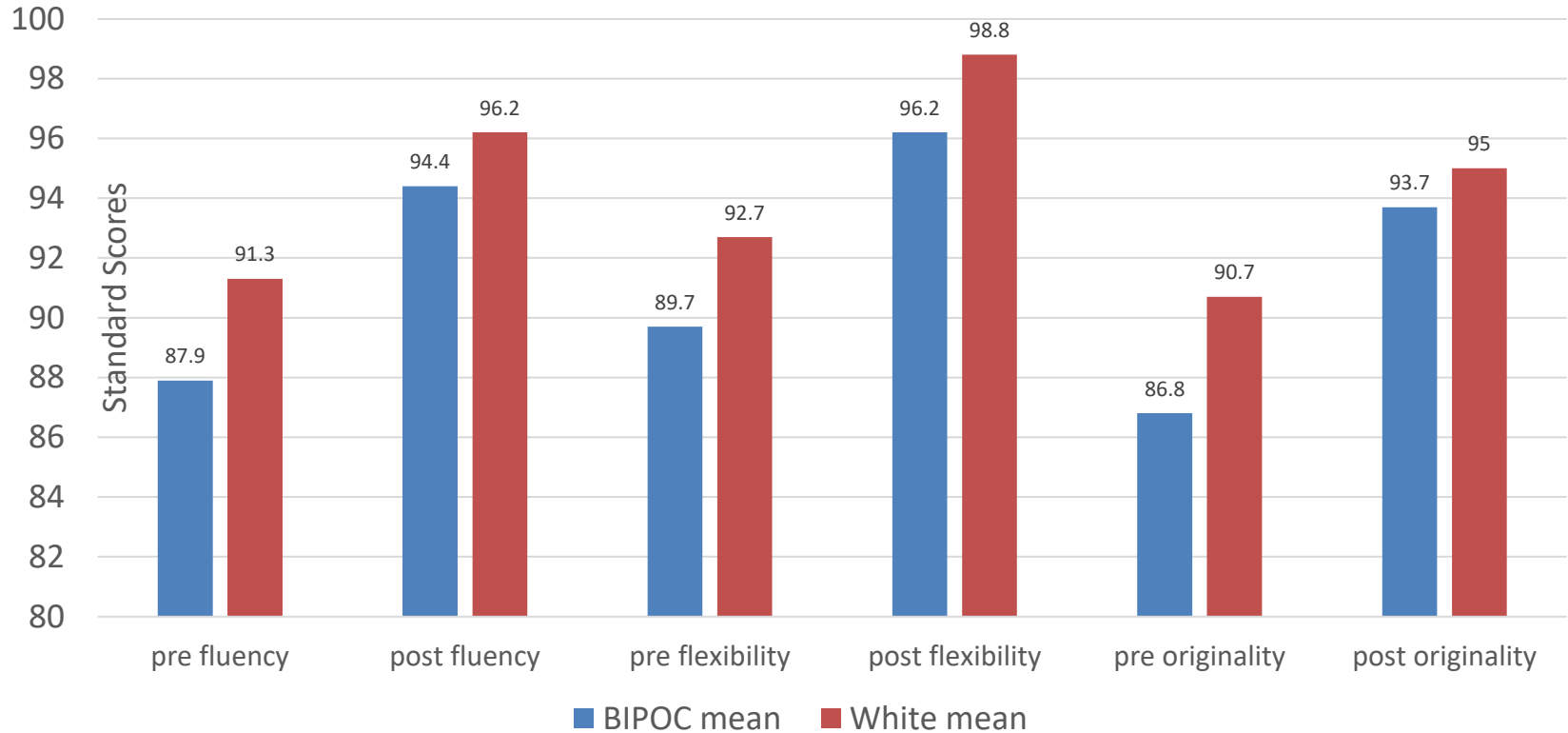
# Examined Hometown

- Also found no statistically significant differences between groups (e.g. city vs. rural)
- Did see some **tendencies for "rural" students to score higher**, but without statistical differences

# Examined Intended-Majors

- Found no statistically significant differences between groups (e.g. biology-intended vs. genetics-intended, etc) with the exception of

- **Flexibility scores statistically higher with Zoology-intended students** compared to the other intended-majors (F=2.75, p=0.018)

  - Zoology highest with 112.9 & BA Biology lowest with 90.8

# In Conclusion



- Students **can grow** in their creative thinking skills in just one semester
- It is easy to **restructure assignments** you might already do with your students to have a more intentional creative thinking development component to them

# **Acknowledgements**

- Many thanks to the statisticians who analyzed the TTCT data:
    - Xhoana Laska,
    - Kaida Lou, and
    - Lucy Yin

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