

Creativity in Programing



Rod Rowell and Chris Carman

Key Points of Research Analysis

1. Creativity is hard to define and measure.
2. The results of any creativity process must be unique, novel, and appropriate. The creative process can also focus on the process alone.
3. Environments that foster freedom of thought and expression without negative feedback loops (due to failures) allow for better creative results.
4. Open-ended, ill-defined problems in a context allow students to work through a creative process. Students must be taught the process.
5. 21st century skills include creative and critical thinking. How do we fuse the traditional creative arts with computer programming?

Theories of Creativity

Guilford's Four Divergent Thinking Factors (1950's)

1. Fluency. The total number of interpretable, meaningful, and relevant ideas generated in response to the stimulus.
2. Flexibility. the number of different categories or shifts in responses.
3. Originality. the number of unusual yet relevant ideas and the statistical rarity of the responses.
4. Elaboration. The amount of detail used to extend a response (1966, 1974).

[https://geniusrevive.com/en/ellis-paul-torrance-father-of-modern-creativity/#:~:text=Torrance%20devoted%20his%20career%20to%20teaching%20and%20researching%20creativity.&text=Later%20he%20defines%20creativity%20as,the%20hypotheses%E2%80%9D%20\(1962\).](https://geniusrevive.com/en/ellis-paul-torrance-father-of-modern-creativity/#:~:text=Torrance%20devoted%20his%20career%20to%20teaching%20and%20researching%20creativity.&text=Later%20he%20defines%20creativity%20as,the%20hypotheses%E2%80%9D%20(1962).)

Theories of Creativity

Ellis Paul Torrance

Later he defines creativity as “...the process of sensing gaps or disturbing, missing elements; forming ideas or hypotheses concerning them; testing these hypotheses; and communicating the results, possibly modifying and retesting the hypotheses” (1962).

[https://geniusrevive.com/en/ellis-paul-torrance-father-of-modern-creativity/#:~:text=Torrance%20devoted%20his%20career%20to%20teaching%20and%20researching%20creativity.&text=Later%20he%20defines%20creativity%20as,the%20hypotheses%E2%80%9D%20\(1962\).](https://geniusrevive.com/en/ellis-paul-torrance-father-of-modern-creativity/#:~:text=Torrance%20devoted%20his%20career%20to%20teaching%20and%20researching%20creativity.&text=Later%20he%20defines%20creativity%20as,the%20hypotheses%E2%80%9D%20(1962).)

Manifesto for Children (Torrence 1983).

1. Don't be afraid to fall in love with something & pursue it with intensity.
2. Know, understand, take pride in, practice, develop, exploit, & enjoy your greatest strengths.
3. Learn to free yourself from the expectations of others and to walk away from the games they impose on you.
4. Find a great teacher or mentor who will help you.
5. Don't waste energy trying to be well rounded.
6. Do what you love and can do well.
7. Learn the skill of interdependence.

Manifesto for Adults (by E. Paul Torrance and Garnet Millar).

Being a Beyonder means doing your very best, going beyond where you have been before, and going beyond where others have gone.

- 1.The beyonders take delight in deep thinking.
- 2.They are tolerant of mistakes by themselves and others.
- 3.They are able to feel comfortable as a minority of one.
- 4.They love the work that they do and do it well.
- 5.They have a sense of mission and have the courage to be creative.
- 6.They do not waste needless energy trying to be well-rounded.

Torrance Creativity Test

<https://innovators-guide.ch/wp-content/uploads/2012/12/torrance-creativity-test.pdf>

Torrance Test	Starting Shapes		Completed Drawing	
			More Creative	Less Creative
	Use		 Mickey Mouse	 Chain
	Combine		 King	 Face
	Complete		 A fish on vacation	 Pot

Sternberg(2003)

- There are five components of creativity
 - (1)Expertise: a well-developed base of knowledge
 - (2) Imaginative thinking skills: the ability to see things in novel ways, to recognize patterns to make connections
 - (3) A venturesome personality: seeks new experiences, tolerates ambiguity and risk, persevere in overcoming obstacles
 - (4) Intrinsic motivation: driven more by interest, satisfaction, and challenge than by external factors
 - (5) Creative Environment: sparks, supports and refindes ideas.

Key Points of Research Analysis

1. Creativity is hard to define and measure.
2. The results of any creativity process must be unique, novel, and appropriate. The creative process can also focus on the process alone.
3. Environments that foster freedom of thought and expression without negative feedback loops (due to failures) allow for better creative results.
4. Open-ended, ill-defined problems in a context allow students to work through a creative process. Students must be taught the process.
5. 21st century skills include creative and critical thinking. How do we fuse the traditional creative arts with computer programming?

Research: Creativity and Computing

Information technology use and creativity: Findings from the Children and Technology Project

Project Specifications and Goals

- Participants of the study were 491 children of an average age of 12.34 years old.
- Four types of information technology were considered: computer use, Internet use, video game playing, and cellphone use.
- Multiple measures of creativity were developed using Torrance Test of Creative thinking.
- Surveys were mailed to parents and children with a \$25 stipend.
- The goal of the survey was to capture the richness and complexity of the creativity construct.
- The second was to minimize the contribution of alternative constructs to the creativity measure.
- The survey asked participants to respond to two target stimuli to assess creativity.

Project Survey Items

- The survey asked participants to respond to two target stimuli to assess creativity.
- The first stimulus took the form of an “egg” presented alone on a blank sheet of paper with the following prompt.
- “One the following page is a curved shape. Think of a picture or object that you can draw with this shape as a part of it. Try to think of a picture that no one else will think of. Keep adding new ideas to your first idea to make it tell as interesting and exciting a story as you can. When you have completed your picture make up a name or title for it and write it in the space provided under your picture. After you have drawn your picture and given it a title, come back to this page and write a story about your picture below.

Project Survey Items

- The second stimulus was a picture of an elf like figure lying in front of a pool of water, staring at its reflection in the water. Instructions were as follows: “Look at the picture. Think about what is happening. What can you tell is happening for sure? What do you need to know to understand what is happening, what caused it to happen, and what will happen next, as a result? After you have looked at the picture and thought about these questions then go to the next page after the picture.”
 - Write out all of the QUESTIONS you can think of about the picture.
 - List as many possible CAUSES as you can think of for the activity (what is happening) in the picture.
 - List as many POSSIBILITIES as you can think of for what might happen next as a result of what is happening in the picture.

Project Interpretation

- Computational thinking is defined as a broad range of mental tools and concepts from computer science that helps solve problems, design systems, understand human behavior, and engage computers to assist in automating a wide range of intellectual processes (National Research Council, 2010)
- It can be construed that computational thinking is related to creativity, and that together they facilitate interest and performance in the virtual world - the world of video games.
- The effects of computational and creativity on videogame playing is additive

Project Survey Results

- The overall results showed that children who played video games scored higher on Egg story creativity, Elf question creativity, Elf causes creativity, Elf possibilities creativity, number of Egg words and number of QCP (Questions/Causes/Possibilities) Elf words.
- Regardless of the type of video gamer that children played, more play was associated with greater creativity.
- This research is correlational and cannot establish a cause-effect relationship.

Personal Take Away From This Research

- Creativity is better accessible when in a context.
- Creativity is maximized when in a context of personal interest.

A dialogic Framework For Assessing Collective Creativity In Computer-Supported Collaborative Problem Solving Tasks

Framework's Creativity Paradigm

- Creativity should have a balance of convergent and divergent thinking.
- Cropley and Crophey's (2008) extended phase model of creativity to describe the creative process:
 - Preparation, activation, cogitation, illumination, verification, communication, and validation
 - This is an iterative process
 - This model turns the primary focus away from creative products toward creative potential and processes.
 - This shift is important for schools because it shifts traditional narrow understandings of creativity as primarily situated within the individual and in the creative arts domains, toward a more holistic understanding of creative competencies
 - and process as essential to higher-order thinking, reasoning and problem solving across and beyond the curriculum areas (Runco, 2008)

Framework's Creativity Paradigm - Be Vague

- It is generally acknowledged that creative competencies come to the force primarily in problem solving tasks that are ill-defined and ill-structured, rather than routine in nature.
- In ill-structured problems, information required to solve the problem is not entirely contained in the problem statement, steps and solution pathways are not clearly discernible, and therefore, the consideration of multiple ideas and opposing views are often necessary to task success.
- ill-structured problem-solving is directly correlated with creative thinking in the real world, as they both require developing cogent arguments to support divergent thinking and reflective judgment.

Framework's Four Categories of Questions for Computers and Creativity

- As technology improves and increases in its own creative influence and power, at what point does the user lose creative influence?
 - How Can Computers Enhance Human Creativity?
 - Could Computer Creativity Ever Be Properly Valued?
 - What Can Computing Tell Us About Creativity?
 - How Does Creativity and Computing Matter to Education?

How Does Creativity and Computing Matter to Education?

- As an computer science educator, these questions are a concern.
- Questions #17
 - How then can we change the perception of computing so that programming is seen as an engaging creative subject in the same way as science, music, and the arts?
 - How can we then inspire students to develop their creativity through computing?

How Does Creativity and Computing Matter to Education?

- As an computer science educator, these questions are a concern.
- Questions #18
 - How can we persuade people in education and the arts that programming can be a creative act, with its own creative practice?

How Does Creativity and Computing Matter to Education?

- As an computer science educator, these questions are a concern.
- Questions #19
 - What kinds of environments provide the right level of feedback, intuition and control to inspire the idea of programming as a creative act in early learning?

How Does Creativity and Computing Matter to Education?

- As an computer science educator, these questions are a concern.
- Questions #20
 - Can we find new ways of revealing and explaining computational processes where the flow of computation is more readily accessible to an audience, particularly students?

How Does Creativity and Computing Matter to Education?

- As an computer science educator, these questions are a concern.
- Questions #21
 - Many companies are now beginning to recognise that they want technologists who can think like artists, yet mainstream computing education focuses mainly on engineering-based problem solving.
 - How can we design new universities computing programs to ensure that graduates have the necessary knowledge and skills that allow them to achieve their creative potential?

My Personal Take Away

- Creativity must be given space and time to be developed.
- Creativity is a response to vague problems that are not well defined nor clear in the solution path.
- Creativity can be derived by generating multiple ideas, gaining feedback from those ideas, and choosing the appropriate path.

Key Points of Research Analysis

1. Creativity is hard to define and measure.
2. The results of any creativity process must be unique, novel, and appropriate. The creative process can also focus on the process alone.
3. Environments that foster freedom of thought and expression without negative feedback loops (due to failures) allow for better creative results.
4. Open-ended, ill-defined problems in a context allow students to work through a creative process. Students must be taught the process.
5. 21st century skills include creative and critical thinking. How do we fuse the traditional creative arts with computer programming?

AP CSP: Code Your Self-Worth

- In my AP Principles of Computer Science class we have learned how to program and draw with the turtle in Python.
- I posed the task to my students:
 - Write a program that will create a drawing of your self-worth.
- You are a fruit tree on a happy earth!
 - [Code](#)
 - [Video](#)
- Because like the rose, I am able to bring joy to others despite the thorns
 - [Code](#)
 - [Video](#)

Creativity in Computer Science Education

Computer Science curricula investigated

- Ohio K-12 Computer Science Standards
- AP Computer Science Principles (AP CSP)
- Girls Who Code
- Code.org
- Google's CS First
- Carnegie Mellon CS Academy

Ohio K-12 Computer Science Standards

- [Ohio's Model Curriculum for Computer Science](#) was adopted by the State Board of Education in December 2018
- The Model Curriculum does not directly address creativity, but it includes a statement about "computational thinking":
 - "**Computational Thinking** is a problem-solving process that students use to engage with concepts in the computer science standards. This thinking involves formulating problems in a way that can be carried out by a computer. Using computational thinking to solve a problem includes breaking down the problem into manageable parts; recognizing patterns; excluding irrelevant details to abstract or identify general principles that generate these patterns; and developing step-by-step sequences or algorithms to solve the problem and similar problems."

AP Computer Science Principles (AP CSP)

- AP CSP was launched in 2016 in what the College Board calls "[the largest course launch in AP Program history](#)"
- In 2019, nearly 100,000 students took the AP CSP Exam
- The new course was "designed to change the invitation and to attract students from a broader range of groups to computer science"
- Supplements the existing AP Computer Science A (AP CS A) Exam, which teaches Java programming
 - Around [70,000 students](#) took the AP CS A Exam in 2019
- A [study published in December 2020 by College Board](#) found "AP CSP students are more diverse than AP CSA students, and AP CSP often provides the first AP STEM experience for Black, Hispanic, and first-generation students who take it"

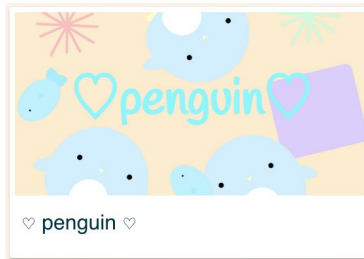
Creativity in AP Computer Science Principles

- AP CSP is organized by five "[Big Ideas](#)"
- The first Big Idea is **Creative Development**, which makes up 10-13% of the AP Exam and includes these topics:
 - Collaboration
 - Program Function and Purpose
 - Program Design and Development
 - Identifying and Correcting Errors
- The AP Exam also includes a Create Performance Task, where students "design and implement a program that might solve a problem, enable innovation, explore personal interests, or express creativity"
 - worth 30% of the total Exam score

Girls Who Code

- [Girls Who Code](#) (GWC) was launched in 2012 by Reshma Saujani
- Over 8,500 programs worldwide, including 375,500 after school clubs for girls to explore CS in a fun and supportive environment
- By emphasizing creative projects and activities, GWC aims to interest girls in CS at a young age so that they're more likely to pursue it as a career
- Kent Girl Coders Club is a GWC affiliate





♡ penguin ♡



Griffin Basketball!



Duck Chase



Among Us (Coded on Scratch)



Horseriding



Medium of Transportation



Plant Watering Device - MicroBit



Interactive Art

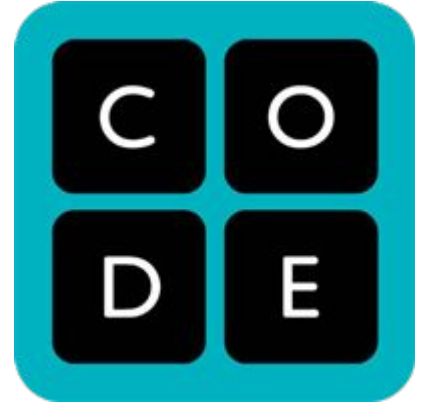


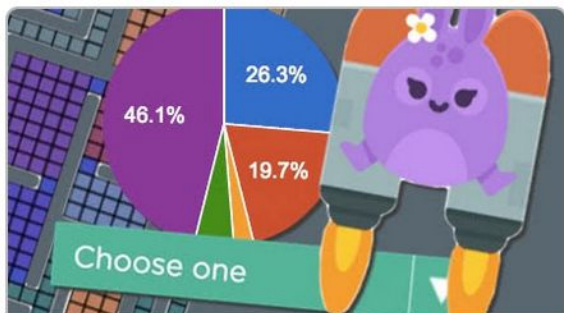
Birthday Party

Examples of creative projects from members of Girls Who Code

Code.org

- Code.org was founded in 2013 by Hadi and Ali Partovi
- Nonprofit that aims to expand access to CS in schools and increasing participation by young women and students from other underrepresented groups
- [30% of all students in the US](#) are enrolled in Code.org to learn introductory CS
- Created the annual [Hour of Code](#) campaign, which has engaged more than 15% of all students in the world
- Kent Girl Coders have hosted the Hour of Code three times for all students in the Kent City School District





App Lab

Design an app, code with blocks or JavaScript to make it work, then share your app in seconds.



Game Lab

Game Lab is a programming environment where you can make simple animations and games with objects and characters that interact with each other.



Web Lab

Web Lab is a programming environment where you can make simple web pages using HTML and CSS. Design your web pages and share your site in seconds.

Examples of creative projects in the Code.org curriculum

Coding Club encourages girls to learn computer science



▲ HIDE CAPTION

Maggie Pazderak, 10, is being helped by Katherine Logue, 13, of Kent, at the Stanton Middle School's the "Hour of Code" event on Saturday. - Photo by Dan Perez



▲ HIDE CAPTION

Iris Amore, 11, is being helped by eighth-grader Emma Arthur during the "Hour of Code" on Saturday. - Photo by Dan Perez

Kent Girl Coders hosting the Hour of Code in 2019

Google's CS First

- [CS First](#) is a free CS curriculum that was launched in 2014 and designed for students in grades 4-8
- Uses video tutorials and block-based coding in [Scratch](#) with different themes like sports, art, and game design
- Part of the "[Code with Google](#)" resources
- Over 10 million lessons delivered
- Integrates with Google Classroom to keep track of students' progress
- Designed by educators for teachers who don't have CS experience





An Unusual Discovery

Introductory 1 lesson 1-2 hours

Two characters meet in a world, discover a surprising object, and decide what happens next.



Art

Intermediate 8 lessons 8-12 hours

Create animations, interactive artwork, photograph filters, and other exciting projects.



Storytelling

Beginner 8 lessons 8-12 hours

Storytelling emphasizes creativity by encouraging students to tell fun, unique, and interactive stories.



Game Design

Advanced 8 lessons 8-12 hours

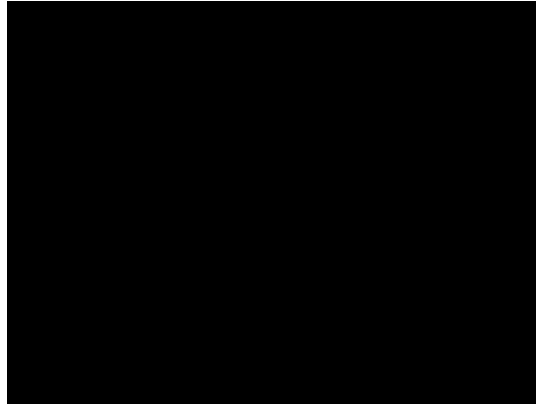
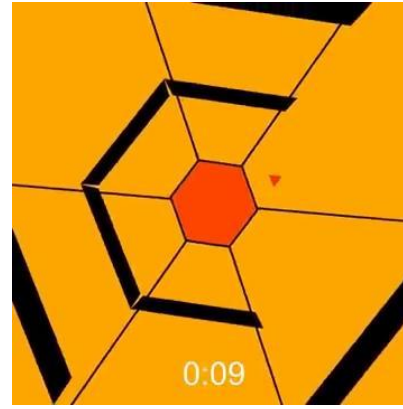
Learn basic coding concepts by making different types of video games, including racing, platform, launching, and more!

Examples of creative projects in Google's CS First curriculum

Carnegie Mellon CS Academy

- [CMU CS Academy](#) is a free, graphics-based CS curriculum provided by Carnegie Mellon University based in Python
- emphasis on "creative programming" in freeform projects that include art, games and algorithms
- Used by over 900 teachers for over 26,000 students
- Used for "Intro to Computer Science" course at Roosevelt High School in Kent





Examples of creative projects in CMU's CS Academy curriculum

The future of creativity in computer science

- According to the [US Bureau of Labor Statistics](#):
 - "Employment of **web developers and digital designers** is projected to **grow 8 percent** from 2019 to 2029, much faster than the average for all occupations. Demand will be driven by the continued popularity of mobile devices and ecommerce."
 - "Employment of **software developers** is projected to **grow 22 percent** from 2019 to 2029, much faster than the average for all occupations. Software developers will be needed to respond to an increased demand for computer software."
 - "Employment of **computer and information research scientists** is projected to **grow 15 percent** from 2019 to 2029, much faster than the average for all occupations. Job prospects are expected to be excellent."
- Reaching students early on by encouraging their creativity can help them pursue a career in computer science that pays well and has job security

Acknowledgements

- Kent State University
- Choose Ohio First Scholarship Program