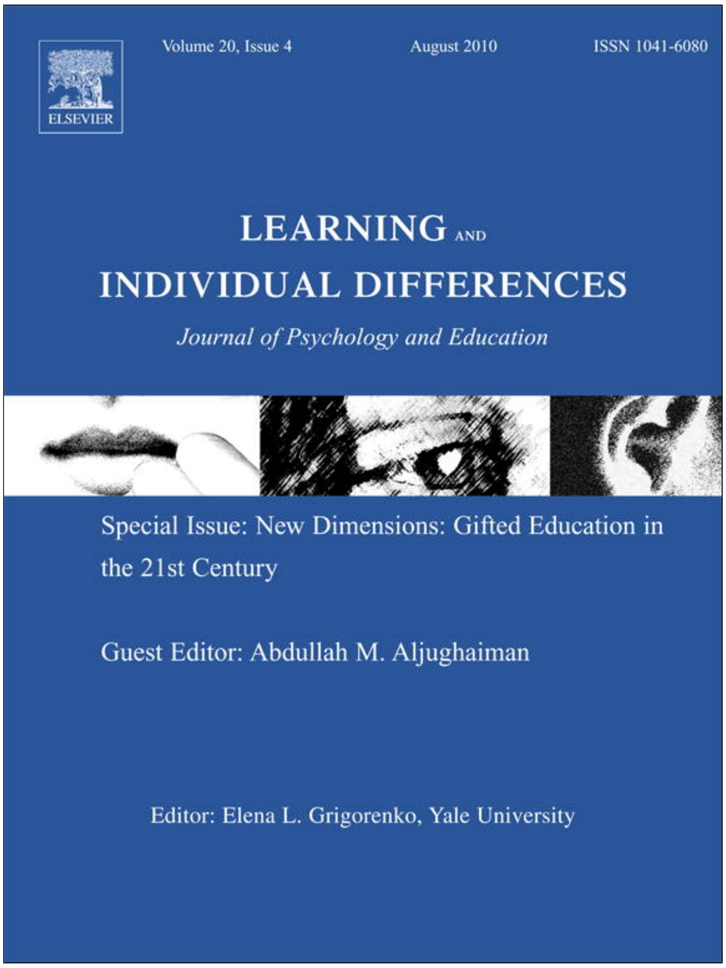
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Creativity polymathy: What Benjamin Franklin can teach your kindergartener

James C. Kaufman [a,*], Ronald A. Beghetto [b], John Baer [c], Zorana Ivcevic [d]

[a] Learning Research Institute, California State University at San Bernardino, 5500 University Parkway, San Bernardino, CA 92407-2318, United States
[b] University of Oregon, Eugene, OR 97403, United States
[c] Rider University, 2083 Lawrenceville Road, Lawrenceville, NJ 08648-3099, United States
[d] Tufts University, 490 Boston Ave, Medford, MA 02155, United States

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ABSTRACT

Creative polymathy at the very highest levels is rare, but this is largely the result of a long period of training usually necessary to become proficient in any field. We explain why creative polymathy is not ruled out by arguments for the domain specificity of creativity and argue that consideration of multiple levels of creativity (Big-C, Pro-c, little-c, and mini-c) leads to the conclusion that creative polymathy may actually be fairly common. We introduce a hierarchical model of creativity (the APT Model) to help understand some constraints on and possibilities for creative polymathy, suggest different ways creative polymathy may be expressed, and offer guidelines for recognizing and nurturing creative polymathy in students.

Benjamin Franklin may have been the Unites States' first true contribution to creative polymathy. He was an inventor, creating a clean-burning stove, bifocals, and the lightning rod. He was a scientist, charting out the Gulf Stream and discovering new properties of electricity. He was a literary success, writing and editing *Poor Richard's Alamanack*; his autobiography is still a regularly assigned college reading. He was a civic leader, helping to create the University of Pennsylvania and one of the first public lending libraries. And, of course, he was a political genius, being a founding father of America and subsequently ambassador to France. His legacy continues to this day. Whereas many other early founders of the United States (such as John Hancock or John Adams) are remembered in name only by most of the general public, Franklin lives on — as a lead character in two different Broadway musicals (*1776* and *Ben Franklin in Paris*), as a common source of quotations, as namesake to fictional characters ("Hawkeye" Pierce on *MASH* and Lt. Pinkerton in *Madame Butterfly*), and immortalized on the hundred dollar bill (Isaacson, 2004).

Creative accomplishment in so many different areas is extremely rare. Imagine someone alive today with the satiric literary wit of a Jon Stewart, the political insights of an Orrin Hatch or Ted Kennedy, the civic mindedness of an Erin Gruwell (the teacher who founded the Freedom Writers), and the general magnetism and charisma of a Tom Hanks or Will Smith. Searching for a handful of modern day women and men who can join the ranks of Leonardo da Vinci, Paul Robeson, Clare Booth Luce, Bertrand Russell, and Linus Pauling, however, can be an exercise in frustration. We believe, however, that just because there are so few highly accomplished multi-creative individuals does not mean that creative polymathy (i.e., being creative in more than one domain) is impossible. Rather, as we will discuss, we believe it is possible to both identify and nurture the multi-creative abilities of gifted students. So the question is not so much is multi-creative ability possible (it certainly is), but rather how might educators nurture the multi-creative talent in gifted students?

In tackling the question, we first consider the question in light of the Four-C model of creativity (Kaufman & Beghetto, 2009). We will then examine two positions about the nature of creativity itself. Position one argues that creativity is a *general* construct (i.e., the skills that lead to creative performance are the same, or very similar, across all domains). Position two argues that creativity is a *domain-specific* construct (i.e., the skills that help one be creative in one domain would be of little use in other, unrelated domains). We then describe a more balanced position by drawing on the Amusement Park Theoretical (APT) Model (Baer & Kaufman, 2005a,b; Kaufman & Baer, 2004, 2006). We conclude by presenting a marionette analogy to help illustrate how a gifted student might be creative in multiple domains, which varies depending on their level of creative development.

1. The Four-C model of creativity: Big-C and little-c

> "If you would not be forgotten as soon as you are dead, either write something worth reading or do things worth writing."
> – *Benjamin Franklin*

Prior to understanding how multi-creative ability might be identified and nurtured in gifted students it is first important to understand what it means to be creative. Two studies of creativity typically focus on legendary (Big-C) expressions of creativity and everyday (little-c) expressions of

* Corresponding author. Tel.: +1 909 537 3841.
E-mail address: jkaufman@csusb.edu (J.C. Kaufman).

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creativity (Csikszentmihalyi, 1996; Stein, 1953). Studies of Big-C creativity often have the goal of learning about creative genius and which explore the types of creative works that may last forever (e.g., Simonton, 1994). Big-C creators typically have devoted many–usually ten or more–years of intense study developing the requisite domain expertise necessary for making revolutionary contributions (Ericsson, Roring, & Nandagopal, 2007; Simon, 1981; Simonton, 1997). Big-C creators typically are remembered years after their death; their life and works may be studied by subsequent generations — consider Charles Dickens, Albert Einstein, Oscar Wilde, Jane Austen, or Duke Ellington. Creative greatness may be studied by analyzing the lives of well-known creators, or interviewing renowned individuals, or perhaps by studying people who excel at high levels on creativity measures. Big-C creativity has, traditionally, been the focus of much research and theorizing in creativity studies (see Simonton, 2009, for a review of many of these studies).

Creativity researchers have also focused on more everyday or little-c experiences of creativity (Richards, 1990). Everyday or little-c creativity highlights the creativity involved in the daily activities and experiences in which just about anyone can participate. Examples of little-c creativity include: making up song lyrics to a favorite song, figuring out new ways to motivate your roommate to finish cleaning up her mess in the kitchen, combing leftovers into a tasty new synthesis of flavors, or your toddler coming up with a new story-line for his or her favorite picture book.

Although it may seem that these two common categories of creativity (Big-C and little-c) account for just about any expression of creativity, on closer expression it becomes evident that these two categories do not sufficiently account for subtle, yet meaningful distinctions in levels of creativity. Consider, for instance, a musician who has performed at several major venues, but may never attain the status of an eminent musician (whose work is featured on radio shows or taught in music classes). This musician clearly is not a Big-C performer, but to categorize her as a little-c musician would diminish her professional success (as she would be lumped in with the occasional musician who plays music for family and friends and may not be able to perform in a concert hall). The professional musician, when considered in light of the Big-c/little-c split, is misplaced or obscured. The same can be said for the much more subjective creativity of a student learning how to play music. Although the student may have new and personally meaningful insights about how to combine notes while playing, such insights may not be sufficiently novel to be considered creative even at the little-c level. Given these limitations with traditional Big-C/little-c conceptions of creativity, Kaufman and Beghetto (2009) proposed the *Four-C Model of Creativity*; which added the two categories of "mini-c" creativity (Beghetto & Kaufman, 2007) and "Pro-c" creativity (Kaufman & Beghetto, 2009).

1.1. What is mini-c?

"Tell me and I forget. Teach me and I remember. Involve me and I learn."– *Benjamin Franklin*

The mini-c category focuses on the novel and personally meaningful insights and interpretations involved in learning and experience (e.g., a new insight into how to solve a math problem, a new connection between what has been learned in science and history class). Mini-c creativity includes the "personal" (Runco, 1996, 2004), "expressive" (Taylor, 1959), and "developmental" (Cohen, 1989) aspects of creativity. Examples of mini-c creativity include a student having a personally meaningful insight that helps her make a connection between an algebraic equation and the calculations needed for her science fair project; a youngster making a new connection between the design of building he saw on summer vacation and the Lego towers he now makes at home, or a teacher watching a historical documentary on television and having a new insight about how to incorporate math into a social studies lesson.

The definition of mini-c creativity (Beghetto & Kaufman, 2007) stresses the importance of personal (or subjective) judgment of novelty and meaningfulness. This focus on subjective judgment distinguishes mini-c creativity from more objective expressions of creativity in which the novelty and meaningfulness of the outcome requires external judgment. Consequently, mini-c insights many never go beyond the individual creator. On the other hand, however, just because mini-c creativity does not meet the traditional standards used for judging Big-C or even little-c creativity (the production of a product that is externally judged to be novel and meaningful) mini-c creativity can and should be considered a sign of creative *potential*. As Vygotsky (2004) has argued, internal creative acts can still be considered creative, even when they only take the form of "some mental or emotional construct that lives within the person who created it and is known only to him" (p. 7).

Consider a child learning to finger-paint. His painting may not bring anything "new" to the domain of art; it may not be entirely within the typical confines of painting (perhaps it is a painted pinecone), and he may demonstrate no special talent or aptitude (more paint may end up on his clothing than on the paper). Yet there is nonetheless a core of internal creative expression taking place: for instance, he is discovering new and personally meaningful ways to combine color and how to represent images on paper. Such mini-c insights and interpretations, while valuable in their own right, can also serve as building blocks on which further creative insights and expression might be produced (he may end up creating personalized holiday cards that his family recognizes as creative, or make his own comic book that is judged by peers, teachers, or perhaps even established creators of graphic novels to be creative). In this way, mini-c creativity can (and often does) serve as the genesis for more objective levels of creative expression.

The concept of mini-c creativity also underscores the relationship between creativity and personally meaningful learning. This connection was recognized more than fifty years ago by J.P. Guilford (1950), who argued that "a creative act is an instance of learning" and, therefore, "a comprehensive learning theory must take into account both insight and creativity activity" (p. 446). As such, any time a student has a unique and personally meaningful insights or interpretation when learning a new discipline it can be said that the student has engaged in a personally creative act and an instance of personally meaningful learning. This is true even if no one else recognizes the insight as unique or particularly meaningful (indeed there is some distance to travel, which often includes focused learning of the conventions of a particular domain, before a mini-c insight can develop into an idea, product or behavior recognized by others as creative).

Even though we argue that there is a relationship between personally meaningful learning and mini-c creativity, we also recognize that not all aspects of learning are creative. Someone learning a series of vocabulary words by rote, for example, likely would not be experiencing mini-c (as this may not lead to any new or personally meaningful insights or interpretations). Mini-c creativity may still occur, however, if the student learning the series of vocabulary words used his or her imagination to form mental connections (i.e., "headstrong means being stubborn and willful; in order to do that, you need a strong head").

1.2. What is Pro-c?

"Genius without education is like silver in the mine."
– *Benjamin Franklin*

Pro-c creativity includes professional-level creators who have not yet attained legendary status (Kaufman & Beghetto, 2009). Someone who is a hobbyist and creates point-and-click games using free shareware falls into the little-c category, whereas Sid Meier (the *Civilization* games) and Will Wright (the *Sims* games) are likely examples of Big-C. The Pro-c game designer, in contrast, would be someone who has worked as part of a team on a well-reviewed game, or has perhaps created an iPhone game that is popular as a paid download. The distinctions between these levels of creativity are based purely on the amount of revenue generated (although that can play some role). Rather, the distinction pertains more to expertise and level of impact. The game designer creating highly popular iPhone games is clearly beyond any amateur status — but is not necessarily close to leaving a permanent mark on the field. Many professionals in a variety of disciplines (e.g., anthropologists, business management professors, stage lighting designers, chefs, public relations consultants) would also be considered examples of Pro-c creators.

The Four-C model's specific categories are described in Table 1.

2. The Four-C model and multi-creative potential

As we have discussed, the Four-C model helps broaden conceptions of creativity to include everything from the more subjective, mini-c creative insights and potential to the more objective and clear cut examples of Big-C creative eminence. But how might this model be helpful in identifying and nurturing the multi-creative potential of gifted students? One important way that it is helpful is that it allows researchers to consider the likelihood of expressing multi-creative potential across the various levels of creative magnitude (Beghetto & Kaufman, 2009).

If one begins at the Big-C level, for instance, the likelihood of a teacher identifying a legendary creator in his or her classroom is near impossible. As discussed earlier, Big-C creativity requires recognition by critics, historians, or other relevant gatekeepers of a domain — not to mention the many years of intensive study to develop the expertise necessary for eminent creative achievement. This makes it extremely difficult to predict whether a particular youngster will be capable of a Big-C contribution in one domain, let along across multiple domains. Multi-creative ability, spanning more disparate fields, seems more likely when you consider creative achievement at lower levels of creative expression. Indeed, Root-Bernstein (1989) has documented 400 cases of famous scientists who were also highly skilled in the arts. Galileo is best known for his legendary work in science; however, he was also a skilled artist and musician.

When it comes to individuals who have multi-creative talent at a professional-level, it isn't difficult to list several examples. Consider, for instance, Byron "Whizzer" White (athlete and Supreme Court justice), Arnold Schwarzenegger (actor and politician), Rachel Ray (cook, writer, talk show host, entrepreneur), Sofia "Sonya" Kovalevskayas (mathematician, writer and political activist), and Omar Sharif (actor and bridge player). The list quickly expands when Pro-c and little-c levels are combined. Thinking of anyone at the Pro-c level who also is creative at an everyday level in a different domain is quite easy (e.g., accomplished academics that also have vocations in areas such as cooking, poetry, art, music, theatre, photography).

At the little-c and mini-c level, it probably is more likely to find creative polymathy than not. Many people have multiple everyday creative avocations (cooking, gardening, photography, story-telling), and mini-c polymathy can occur anytime someone combines new and personally meaningful insights and interpretations across different disciplines or domains. For instance, a student might have a mini-c insight about how to incorporate design principles that she is learning in her art class into the poster-presentation of her science experiment for her school science fair.

Table 1
The Four-C model.

	Brief definition	Example	Types of measures
mini-c	Novel and personally meaningful interpretation of experiences, actions and events.	Student's new and meaningful insight about how to use a strategy learned in math class to analyze data in her science fair project.	Self-assessment, micro genetic methods.
little-c	Everyday expressions of novel and task appropriate behaviors, ideas or products.	Combing left over Italian and Thai food into a new and tasty fusion of flavors that your family enjoys.	Ratings (teachers, peers, parents); psychometric tests (e.g., Torrance tests); Consensual assessment.
Pro-c	Expert expressions of novel and meaningful behaviors, ideas or products (that exceed everyday but have not attained legendary status).	A professor's psychological study that receives an award from a professional psychological association.	Consensual assessment; peer review; prizes/honors.
Big-C	Legendary novel and meaningful accomplishments, which often redirect an entire field of study or domain.	The scientific theories of Isaac Newton. The innovative social justice work of Martin Luther King, Jr.	Major prizes/honors; historiometric measures.

3. The domain specificity v. domain generality paradox

Even though we have just argued that multi-creative ability–particularly at the little-c and mini-c level–is relatively common, research on creativity across multiple domains (at the little-c level) suggests that creativity may be very domain-specific. This seems to present a paradox. The research on domain specificity does seem to rule out polymathy, because if the skills that underlie creativity are completely different in different domains, then the skills a person has that lead to creativity in one area would be of no value at all in other domains. How then could one person be creative in multiple domains? In order to resolve this seemingly paradoxical situation, we must first try to understand what research does in fact say about domain specificity.

If creativity is domain general, it would be expected that different creative behaviors would be highly correlated each other and with a common set of psychological descriptors for those behaviors. If creativity is domain specific, it would be expected that different creative behaviors would be poorly correlated or uncorrelated among each other, and that there would be a diverging set of psychological descriptors of those behaviors (Ivcevic, 2007).

Baer, for example, has explored this issue in samples of students ranging from second graders to college. He had these students produce creative work through writing poetry, writing short stories, telling stories out loud, creating mathematical equations, creating mathematical word problems, and making collages. Baer consistently found low and usually non-significant correlations between ratings of creative performance in these different areas (Baer, 1991, 1993, 1994, 1996). In other words, a student who wrote a creative poem was not more likely to also tell a creative story, make a creative collage, or write a creative mathematical equation (a creative algebraic equation might use numbers in a playful or unusual way). Several other studies (e.g., Han, 2003; Runco, 1989) have found similar results. And if you remove variations due to IQ, the small correlations get even smaller.

Other researchers, for example, Conti, Coon, and Amabile (1996) analyzed data from studies in which subjects had both written stories and engaged in art activities. The intercorrelations among the creativity ratings of the stories were high, confirming the prediction that "creativity measures within the same domain are substantially inter-correlated" (p. 387). Intercorrelations of creativity ratings among the art tasks, which were more unlike one another than were the story-writing tasks, were positive but somewhat lower. But within-domain correlations tell us nothing about the domain specificity/generality question. Cross-domain correlations, on the other hand, speak directly to the generality-specificity question. None of the 13 cross-domain correlations that Conti, Coon, and Amabile reported–the crucial tests for domain generality–was statistically significant, and the mean of these 13 correlations was just 0.109, accounting for just a little more than one percent of the variance.

Not everyone, of course, is convinced by the evidence favoring domain specificity (see, e.g., Plucker, 1998, 2005; Plucker & Beghetto, 2004). Research that looks at actual creative products tends to yield results like those just cited favoring domain specificity, but whereas personality-based studies or traditional psychometric methods tend to find that creativity is domain-general (Plucker, 1998). One common psychometric method is to use a divergent-thinking test, such as the Torrance Tests of Creative Thinking. The Torrance Tests assume domain generality and therefore offer no way to evaluate the possibility of domain specificity. Self-report scales sometimes support a combination of domain-general and domain-specific viewpoints. For example, Hocevar (1976) found "low to moderate" (p. 869) correlations among self-report indexes of creativity in various domains among college students. In a study in which several thousand subjects self-reported their own creativity in 56 domains, Kaufman, Cole, and Baer (2009) found both an over-arching general factor and seven more specific areas of creative performance.

The issue of domain specificity/generality remains an open question in creativity research. Because domain specificity would seem to argue against the likelihood of finding polymaths, however, we need to explain why even if the domain specificity theorists are right, this would still not rule out the possibility (or even likelihood) of creative polymathy. With that concern out of the way, we can then present our model, a model that includes features of both the domain-general and domain-specific approaches, and explain how polymathy fits into this wider conception of creativity.

4 . Why domain specificity does not rule out creative polymathy

Proponents of domain specificity don't claim that no one has a multitude of creative abilities (just as they don't claim that everyone is creative in one domain or another). Their argument simply says that (a) the skills that underlie creativity vary by domain and (b) the presence or absence of any particular skill or set of skills (or the degree to which these skills exist, because they are not dichotomous, either/or kinds of abilities) in any one individual involves a degree of randomness (e.g., chance encounters, experiences, or opportunities that support–or undermine–the development creativity-relevant skills in a domain). Based on this argument, a small fraction of people would be expected to have severely underdeveloped creativity-relevant skills in just about any domain; many people will have developed modest amounts of skills in several domains; some will have a developed a great deal of skill in one or more domains; and a few will have developed great quantities of such skills in many domains. Here's an analogy: If there were a thousand each of red, blue, green, and orange flags that were randomly distributed among one hundred people, a few people might end up with no flags at all and a few other people might end up with several dozen flags of every color. Most people would get some mix, which might be a modest number of flags of all colors or lots of flags of some colors and few of other colors. That's how randomness works. Of course, just because the development of creativity-relevant skills involve some degree of randomness does not mean that underdeveloped creativity in a particular domain can never be developed. Rather, understanding the role that chance plays in the development of creativity-relevant skills helps explain the distribution of people who have (or have not) developed the skills requisite for creative expression within or across domains.

Benjamin Franklin, from a domain-general interpretation, would be thought to have a great deal of creativity, which he simply applied to all the different fields that interested him. From a domain-specific interpretation, however, Franklin's multi-creative talent would be explained by claiming that he happened to have a great deal of creativity-relevant abilities in many domains. The talents that led to his success as a politician need not be the same as (or even overlap at all with) the skills that helped him be a great inventor, and neither set of skills might have had anything to do with his success as a politician or writer. There may have been overlap, but there need not have been. Someone can be talented in math and also be a good tennis player, and yet these may be entirely distinct domains that are based on completely different underlying abilities. Being creative in two seemingly unrelated areas doesn't show that creativity is domain-general anymore than the existence of a mathematically talented tennis expert would prove that tennis and math are rooted in the same set of skills. Domain specificity, even in its most extreme form, doesn't argue that people can be creative in only a single domain. It simply argues that because the abilities that make creativity possible in different domains are different, creative performance in one domain doesn't predict creativity in other areas. If domain-based talents are randomly distributed, then one should find a few people who have a great deal of creativity-relevant skills in many domains, some people who have talents (of varying degrees) in several domains, and some who have little talent in any domain. This is what a normal distribution of unrelated skills would predict. So the presence of a few polymathic Renaissance people wouldn't contradict domain specificity. In fact, it is precisely what domain specificity predicts.

One of the most important aspects to keep in mind when considering the rarity of legendary creative polymaths is that it simply takes a great deal of time to develop the skills necessary to produce creative work in any one particularly domain (Gruber & Davis, 1988). According to the "ten-year rule" (Hayes, 1989) it takes, on average, at least ten years of preparation in a given domain prior to reaching the highest levels of creative accomplishment in that domain, (Weisberg, 1999). It, therefore, should come as little surprise that few people manage to reach those highest levels in more than one (or perhaps two or three at most) fields in a single lifetime.

Importantly, neither the domain general nor domain specific models of creativity rule out the possibility of there being many people who might be Big-C creative in one domain and also Pro-c creative in several others, or simply Pro-c creative in many fields (under the assumption that the ten-year rule limits Big-C creativity far more than Pro-c creativity). And domain specificity certainly does not lead one to expect a scarcity of polymaths at the little-c or mini-c levels (Domain generality would lead us to expect polymathy to be even more widespread than would domain specificity, but neither theory makes specific predictions.). In the next section we present a model that can provide a framework for the many kinds (and degrees) of creativity that we see in the world, a model that we believe can help us understand both single talents and polymathy. It can also help us in identifying promising approaches for identifying the multi-creative potential of students.

5. The Amusement Park Theoretical model of creativity

A theory that can yield (along with the Four-C model) new insights about creative domains is the Amusement Park Theoretical (APT) model of creativity. The details of the model are presented elsewhere (Baer & Kaufman, 2005a, 2005b; Kaufman & Baer, 2004,2005, 2006), so we will simply summarize the key features of this theory to demonstrate how this theory might allow for more " intelligent" creativity testing by highlight the related constructs that could be considered in such an assessment (such as personality)[1]. The APT model is based (perhaps somewhat whimsically, as some of our reviewers have noted) on the metaphor of a large amusement park. (The APT model = the Amusement Park Theoretical model.) In an amusement park there are initial requirements that apply to all areas of the park. For example you will not be admitted with a ticket. You must be wearing proper attire (Disney has yet to sponsor a nudist day), and you must be able to ride on public transportation or have a car to take you to the park. Similarly, there are initial requirements that, to varying degrees, are necessary to creative performance in all domains. For example, in order to be creative at something, you must have a certain base amount of intelligence. You also need to be motivated to be creative, regardless of what factors motivate you. Finally, you should be in an environmental that allows (and, ideally, nurtures) creative expression. All three of these initial requirements are needed for any attempt at creativity to succeed.

[1] The APT model is not the only one to address domain specificity and generality; see Plucker and Beghetto's (2004) Hybrid model.

Amusement parks also have general thematic areas (e.g., at Disney World one might select among EPCOT, the Magic Kingdom, the Animal Kingdom, and Disney–MGM Studios), just as there are several different general areas in which someone could be creative (e.g., the arts, science, business). Once in one type of park, there are sections (e.g., Discovery Island Station, Dinoland, and Rifiki's Planet Watch are all found in the Animal Kingdom), just as there are domains of creativity within larger general thematic areas (e.g., painting and poetry are domains in the general thematic area of the arts). These domains in turn can be subdivided into micro-domains (e.g., the Conservation Station and Wildlife Express Train are both part of Rifiki's Plant Watch; in the domain of poetry, one might specialize in haikus or free verse). Although the initial requirements are only spelled out for the beginning of the model, there are clearly requirements for every descending level. Lubinski and Benbow (2006) argue that personal attributes (abilities and interests) and the environment are of equal importance in determining success and satisfaction. The more that one's abilities and interests match the requirements of the environment, the better.

As an example, if one were interested in assessing the creative abilities of a subject in terms of creativity in psychological research, one might start by assessing such initial requirements as a certain minimal level of intelligence and appropriate motivation and environment, as well as skill in the general thematic areas of language and mathematics. Next one might assess skills in certain domains especially relevant to psychological research (such as statistical acumen, analytic thinking, domain-specific knowledge). Finally, if one was interested only in the ability to (for example) be a neuropsychologist, as opposed to social or clinical psychologist, one might evaluate skills in specific micro-domains specifically related to neuropsychology.

If, on the other hand, one were interested in a student's creative potential in the area of painting, the hierarchy of skills that one would evaluate would be quite different. The initial requirements might be similar (such as motivation), but skills from very different general thematic areas would be of interest (e.g., verbal skills would be less important, whereas spatial ability and aesthetic style would be of much greater interest). The differences would become even greater as one moved down the hierarchy to domains and micro-domains.

Motivation could also be assessed at different levels of such a hierarchy. For example, a student might have strong intrinsic motivation at the level of the general thematic area of science, and this would indicate a tendency toward creative productivity in the sciences in general. Another student may have extremely high intrinsic motivation only in the domain of marine science, however, which predicts a greater likelihood of creativity in that domain but not in other sciences. Or a student's interest at a given point in time might be even more narrowly focused on a micro-domain (for example, a student may have great interest in the reproductive success of certain kinds of mollusks in different environments but show little interest in other areas of marine science).

Ability would certainly be a key determinant of creative success (as opposed to creative motivation or interest). Although actual domain-related ability would be less essential for mini-c insights or even little-c enjoyment, a genuine pursuit of Pro-c (or, of course, Big-C) would require the appropriate ability. As Park, Lubinski, and Benbow (2007) found, math and verbal SAT scores given at age 13 predicted people's accomplishments 25 years later. A person's specific strengths (in this case, math vs. verbal) predicted both patents (math) and literary publications (verbal). Similarly, Wai, Lubinski, and Benbow (2005) found in the same population that math and verbal SAT scores predicted success by occupation — math SAT scores predicted success in science-related fields, and verbal SAT scores predicted success in Humanities-related fields. People who attempt to advance to Pro-c in a domain poorly suited to their abilities may be metaphorically kicked off the ride[2].

[2] Thank you to an anonymous reviewer for suggesting this idea and phrase.

6. Surprising connections

Even within the fairly structured confines of the APT model, there will also always be surprising connections that make sense only upon closer examination. Someone may decide to pick their amusement parks based only on how good the popcorn is at the food court. Someone else may only go to cheap amusement parks (Big Alan's Generic Roadside Attraction). In a similar way, micro-domains or domains may be selected for reasons that are less obvious. Maybe Phil does not have a lot of money. He therefore pursues creative domains that do not require funds to pursue, such as poetry, stand-up comedy, and geology (he finds interesting rocks and looks for patterns in their shapes).

We believe that many interesting creative polymaths can be uncovered within these strange connections. Certainly, in examining people who are creative in two micro-domains, these areas are typically within the same overall general domain. Examples can be found easily; consider the late Jim Carroll. He was a memoirist (*The Basketball Diaries*), a poet, and a punk rock singer ("People Who Died") known for his provocative lyrics. His micro-domains are distinct, but they all center on his possession of a strong narrative voice. Those rare people who are creative in dissimilar areas–like Franklin's accomplishment in politics, science, inventing, journalism, and literature–represent the pinnacle of creative polymathy.

It is the same phenomenon behind the strange bedfellows concept in the APT model that brings us to the distinction between being creative across multiple domains vs. creative polymathy. Most studies that have examined the domain-specific vs. domain-general question have picked their domains — so, for example, Baer (1993) has given students such tasks as story-writing, story-telling, poetry-writing, mathematical equation-creating, mathematical word problem-creating, and collage-making. He found consistently low and usually non-significant correlations between creative ability in these different areas. In other words, a student who wrote a creative poem was not more likely to also tell a creative story or write a creative mathematical equation. As a result, most of these studies supported the idea that creativity is not a general construct that will manifest itself across all areas.

The domain-specific point of view suggests that the underlying components of creativity are probably different from one domain to another. Let's say that Jacob is creative at computer programming and acting. If we believed that creativity was one general thing, we would say that the elements that enable Jacob to be creative in both of the areas are the same. The domain-specific approach would consider such double proficiency the equivalent of being able to both bench press three hundred pounds and recite pi to two hundred places — both neat things to be able to do, but ones that are based on quite different abilities!

Imagine, however, a puppeteer manipulating two marionettes. She is making the first marionette play the piano, and the second marionette is juggling. Both marionettes are engaged in activities and they certainly share a commonality — the same person is pulling the strings for both. But the strings themselves are completely different. We believe that this same marionette analogy can hold for creative polymaths. Whatever components enabled Benjamin Franklin to be a creative writer (such as his sense of humor, his ability to construct pithy quotations, and his facility with language) may have been different than those components that enabled him to be a creative scientist (such as his persistence, his ingenuity, and his ability to craft experiments). And yet he (Benjamin Franklin) was himself the *puppeteer* who was responsible for his creative *marionettes* in those different domains (Kaufman, Beghetto, & Baer, in press).

Like the APT Model, the puppeteer/marionette analogy allows us to consider multiple levels of creative talent or skill. There may be some general abilities (the APT model's initial requirements) that influence creativity in many areas, just as the skill and dexterity of the puppeteer makes it possible for him to manipulate many different kinds of marionettes. But that general puppeteering skill gets one nowhere without specific marionettes, each of which has its own strings to pull and its own possible range of performances. In the same way, an initial requirement like general intelligence may be important for creativity in many areas, but general intelligence alone is not enough. One also needs more specific skills and motivations in particular general thematic areas, and in specific domains, if one is to evidence creativity. And this is true whether one is thinking about genius-level Big-C creativity, high-level Pro-c creativity, or more everyday little-c or even mini-c creativity (although of course the necessary degree of domain-specific talent is far greater at the higher levels of creativity).

How do creative polymaths differ from individuals who are creative in a single domain? Some abilities and traits are helpful for creativity expressed in any (or close to any) domain. For instance, Openness to Experience has been proposed as a personality disposition for creativity (McCrae, 1987). People who are open to experiences will be interested in new ideas and approaches in their work and flexible in examining their ideas. They will question and re-examine commonly held assumptions and imagine new possibilities. These personal attributes similarly help an artist explore and employ new techniques and materials and a scientist see and address gaps in existing knowledge. Openness is also related to wide interests, suggesting another way how this personality disposition can be related to creative polymathy. It is plausible that creative polymaths have more pronounced certain facets of Openness, such as Openness to Ideas.

Another personal attribute related to creativity in most or all domains is intrinsic motivation or a personal disposition to find enjoyment and challenge in work (Amabile, 1983, 1996). Many people are intrinsically motivated for a narrow range of subject matter. A social psychologist might be intrinsically motivated to study interracial relations and implicit prejudice and an oceanographer might be only interested in studying centimeter-scale turbulence in the open ocean. Other people are intrinsically motivated for a wider range of subjects in one domain (e.g., a physical oceanographer interested in both coastal ocean circulation and biological productivity), across related domains (e.g., a psychologist interested in social policy and educational applications of her work), or across very different domains (e.g., a scientist interested in music performance and evolution of music). Intrinsic motivation for a variety of subject matter and multiple domains become an essential personal attribute in creative polymathy. Other such attributes might include social non-conformity (in order to avoid the traps of domain-specific conventions) and a global, broad-ranging thinking style.

In addition to the personal attributes, there are social and cultural factors that either support or discourage creative polymathy. Certain historical periods and associated Zeitgeist can encourage attitudes or interests that facilitate polymathy. The European Renaissance is one such period when religious dogmas were starting to be challenged and new ideas developed in philosophy, science, and the arts. Leonardo da Vinci is the world's most famous creative polymath, having made contributions to in the domains of art, science, and engineering. Another time and place facilitating creative polymathy in the Western world was Victorian England. The Victorian era coincided with the major technological changes of the industrial revolution, an interest in change and innovation, and a mindset of great self-confidence. For instance, Sir Thomas Raffles was the founder of Singapore, a major contributor to the expansion of the British Empire, and the author of a monumental History of Java (which includes detailed accounts of diverse topics such as customs, religion, military, and natural history).

How supportive of creative polymathy is our contemporary society? What do parents and educators mean when they attempt to instill in children that they "can be whatever they want to be"? Are they saying (implicitly or even explicitly) that one can become any one thing (e.g., an engineer or a scientist, a lawyer or a doctor, a senator or even president) or that they could pursue their multiple interests in the arts, biology, and computer science? The point of decision about specialization in education and profession varies greatly across cultures, from educational systems where separation into college and non-college tracks occurs as early as 5th grade to those that largely postpone this decision until high school or college and allow flexibility for change even after graduation. Postponing these decisions can provide more opportunity for individuals to develop, explore, and pursue interests across multiple domains. Entrance requirements into certain activities, such as music or art programs, also vary across cultures, from (generally) widely available music programs in public schools (e.g., in the United States) to highly selective specialized music schools available only to students with early talent (e.g., in Eastern Europe). A person who does not gain entrance to these programs loses an opportunity to learn how to play a musical instrument. Similarly, a student who is stifled by a strict formal approach to music instruction might lose intrinsic motivation for music and abandon it as a meaningful area of expression.

Specific organizations can also be more or less enabling or supportive of creative polymathy. The Media Lab at the Massachusetts Institute of Technology presents itself as a place where "the future is lived, not imagined" and "where traditional disciplines get checked at the door". This philosophy is reflected in the wide range of domains in which the Media Lab's members are engaged, from behavioral economics to nanotechnology, data visualization, and music. Many lab members clearly cross domain boundaries. Some specific examples include Chris Csikszentmihalyi, who developed new technologies aimed at strengthening geographic communities and exhibited his art installations in both North America and Europe; Judith Donath, who created computing interfaces for online communities and exhibited her art at the Institute for Contemporary Art in Boston and several galleries in New York; and Barry Vercoe, who is a renowned composer and a pioneer in computer sound manipulation and audio technology development. Polymathy-supportive environments have sufficiently broad missions to be able to benefit from creativity in multiple domains. Furthermore, they develop a reward structure that provides incentives valued by its members. Note that incentives can be external rewards, such as compensation packages, but they are also flexible supports for continuation of work projects, such as project funding and appreciation for diverse interests.

Given favorable macro-level social or cultural and micro-level organizational supports, what form is creative polymathy most likely to take? In the Renaissance era, it was possible for an individual to master the existing (and comparatively sparse) knowledge on the arts, sciences, and engineering. Today, when the knowledge base in each of these domains is vast, specialization happens out of necessity. The demands of obtaining higher education degrees necessary as a basis for creativity in engineering are such that they do not allow a person much time to pursue other interests in the same time, especially if these interests are not similar in theme or method. As a result, creative polymathy in the information and knowledge ages will most likely take a form of artists becoming interested in new technologies that can further their art, musicians interested in developing improved ways to deliver music to listeners, or scientists and engineers using technology as themes in creating art installations. These individuals create new work at the intersection of multiple domains by seeing connections and synergies where none existed. Similar skills and ideas can contribute to creation in multiple domains.

Another pathway to creative polymathy is one of successive contributions to different domains. In this case, an individual takes several relatively traditional routes to creativity. One can first study computer science and become a creative software developer after multiple years of training and work. At a later time this person can develop a new interest or start pursuing ongoing interests in another domain, again spending long time on training, skill development, and persistent work. In this case, there may be little similarity between the two domains of creation and many employed skills may be domain-specific. Such successive polymathy can have an indirect effect on enhancing creative output in older age. The overall developmental trend indicates that creative output declines in old age (Simonton, 1991). However, for individuals who change their area of work, this trend can be eliminated or reversed (Simonton, 1998).

7. Discovering and supporting talent

There are several important things to keep in mind when considering how use these models to help identify the multi-creative talents of students. First, it is essential to reiterate that we should not expect to find legendary or professional levels of creativity in young students. Their mini-c and little-c creativity may someday grow into larger forms of creative expression, but not all professional or even legendary creators display the extraordinary precocity of Mozart, who at five could read, write, and play music proficiently. There is not a one-to-one correspondence between precocity and later outstanding achievement.

We are not suggesting that educators overlook any young Mozarts in our classes (something almost impossible to do), but rather to emphasize that it is the less extreme (and less obvious) little-c and mini-c talents and interests that we should be working hard to identify. The APT model does not claim that there are no general creativity-relevant skills, just as a good identification program for gifted/talented students should not ignore IQ test scores, but it reminds us that there are many far less general abilities and motivations that are just as important. Young students who show an extraordinary joy in playing with words; children who find delight in making sketches of scenes from the books they love (and who may have what Winner called a “rage to draw” (Winner, 1996, p. 87), in her description of one talented your artist); students who devour books about stars, or architecture, or some other area of special interest: these are all potentially creatively talented children. Any special skill or interest may be evidence of creativity in a given domain or micro-domain. Our search for giftedness and talent should not be limited to those who have high IQs (although those with high IQs should certainly be included as well), and our efforts to nurture talent should, to the extent possible, harmonize with the specific talents that our students exhibit.

Can we expect to find students who exhibit multi-creative ability? Yes and no. Like Benjamin Franklin, our students may exhibit their talents at different times rather than all at once. Franklin's talents as a politician were not apparent early in his newspaper career. But many of his achievements in diverse fields did overlap (his sage-like wisdom certainly informed both his politics and his writing), and so they sometimes will in our students. To the extent possible, we are wise to follow our students' creative muses, which may have their own calendars and schedules. If a student's interests include both music and science, we would do well to nurture both, but if only one talent or special interest is apparent at a given time, then that is the area on which we should focus.

Once identified, what can we do to nurture budding talents and special interests? There are at least two kinds of things that the psychology of creativity tells us are helpful: (1) show interest, but get out of the way, and (2) help students develop domain-relevant skills and knowledge. Here's what we mean.

(1) *Show interest but get out of the way*:

Expressing interest in children's ideas, projects, activities, performances, and passions is helpful. Talking with them (and especially listening to them talk) about their interests, and providing resources they might need (materials, books, tools, instruments, contacts, etc.) are also important. Providing access to academic acceleration (such as AP classes) is also a wonderful chance to challenge children to push their limits and achieve more.

But then we often need to get out of their way. Intrinsic motivation is a wonderful thing. Unfortunately, when extrinsic motivation is added, the net result may be temporarily higher total motivation, but in the long-term it often leads to lower intrinsic motivation. Bribing children (or adults) to do things they already like to do seems to turn fun into work, and extrinsic motivation more generally (e.g., rewards, anticipated evaluation) has this unfortunate long-term effect, while at the same time often decreasing creativity (Amabile, 1996; Baer, 1997b, 1998a,b; Hennessey & Amabile, 1988; Lepper & Greene, 1975, 1978). This effect is not a simple one, and there is dispute in the creativity research community about its generality. There is evidence that rewards that are more clearly targeted or tied to specific behaviors can either have no negative effect or sometimes even enhance creativity (Eisenberger, Pierce, & Cameron, 1999; Eisenberger & Shanock, 2003). But the evidence that extrinsic motivators can decrease both intrinsic motivation and creativity is far too strong to ignore, and the last thing a teacher wants to do, even inadvertently, is to take away a student's joy or passion for being creative.

Perhaps the most common kind of reward/bribe that teachers use with talented students is extra credit. The teacher's motivation is often a positive one–e.g., after noticing that a student has a real passion for creative writing, the teacher may offer extra credit for writing an extra short story or poem–but the likely longer-term effect is not to increase the student's interest, but (somewhat counter-intuitively) to reduce it. We all like getting rewards, so what could seem better getting extra credit for doing someone one already likes to do? The problem is that such well-intentioned bribes tend to have very negative long-term consequences. What was originally something the student did because of genuine interest has become something she does to get points from her teacher, who has (entirely inadvertently) taken over part of the source of motivation and the direction of the student's once entirely self-directed pursuit. If the student who loved creative writing had wanted to write a short story, she would have done so anyway without the extra credit. Instead of pursuing her interest in creative writing in her own way, she writes her poem or story for the external benefits. Perhaps the student would have otherwise spent her writing energies on something of even more interest (such as keeping her blog up to date or collaborating with a friend on a comic strip, her teacher has, quite unintentionally, converted fun into work.

This is not to say that all extrinsic motivation is bad. Students need to learn skills; in order to learn these skills, they need feedback on their performance. Learning to anticipate evaluation is an essential skill. Teachers need to give their students–including their most creative and talented ones–the kinds of feedback they need to develop their skills. Such feedback should focus on providing information that will support improvement–letting students know what they have done well–pointing out how students might continue to improve their understanding of domain conventions and constraints, and helping students modify, develop new, and even abandon ideas, insights, and interpretations in light of the particular domain and task constraints (Beghetto, 2007). When providing such feedback, teachers should also try to minimize social comparison and evaluative pressures and, instead, stress the informative aspects of their evaluative feedback and acknowledge intellectual risk taking of their students (Beghetto, 2005).

It is worth bearing in mind that it is generally far easier to kill intrinsic motivation than to instill it, and teachers should be careful not to use rewards, or evaluations, as tools to motivate students in areas where they already have significant levels of intrinsic motivation. It is often wiser just to get out of the way of such highly motivated students as they pursue their passions than to try to promote or encourage interests that need no promotion (Baer, 1997a).

(2) *Help students develop domain-relevant skills and knowledge*:

It takes many years to learn everything that one might need to know to become an expert (and possibly a Big-C creator) in any field, as noted above. Students therefore need opportunities to learn about the domains that are of particular interest to them, and they cannot wait until those things happen to appear (or fail to appear) in the regular curriculum. If students have special interests and/or talents, we can nurture those interests by providing opportunities for students to learn more, far more than the curriculum generally expects, in their areas of special interest.

This assistance might take the form of arranging for them to participate in special programs (e.g., summer science camps or spelling bees) or simply providing books and other resources. It might involve special training (e.g., voice lessons), curriculum acceleration (as mentioned earlier), or connecting students with others (both peers with similar interests and abilities and adults who might become mentors) who share their passions. Opportunities to learn about the lives (both professional and personal) of Big-C creators in a student's field of interest can also be helpful.

For students who have many special interests and talents–little-c polymaths–teachers might also provide help with time management. A student with many special interests can never have enough time for all that she wants to do, not to mention those pesky things that the world seems to think she has to do (e.g., those other subjects, the ones that might not–at least yet–excite her).

Multi-creative individuals, like Benjamin Franklin, are rare and we are unlikely to encounter many (or any) in our teaching careers. But legendary creators often have many professional or everyday creative talents and interests (Root-Bernstein & Root-Bernstein, 2004), and many students exhibit vary degrees of everyday and, certainly, mini-c creativity when learning various academic domains. One can never know which talents will become the most important to a polymath at any point in one's life. Joni Mitchell thought music would remain a hobby, playing second fiddle to her serious work as a painter (DiMartino, 1998; Weller, 2008); Alan Greenspan pursued being a saxophone player before "falling back" on economics. Benjamin Franklin surely could not have known which of his many talents would become most important to him later in life. So it is with our students. What we can offer them is the chance to develop any, and all, of their creative talents.

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