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# Being Human in the Age of Algorithms: part 7

**Учебное пособие**



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# PREFACE

Настоящее учебное пособие включает актуальные тексты (2017-2018гг.) учебно-познавательной тематики для студентов механико-математического факультета (направления 02.03.01 «Математика и компьютерные науки», 01.03.02 «Прикладная математика и информатика», 38.03.05 «Бизнес-информатика»).

Целью данного пособия является формирование навыка чтения и перевода научно-популярных текстов, а также развитие устной речи студентов (умение выразить свою точку зрения, дать оценку обсуждаемой проблеме).

Пособие состоит из 5 разделов, рассматривающих значение информационных технологий в современном мире. Каждый из них содержит аутентичные материалы (источники: *Aeon, Quanta Magazine, Nautilus*) и упражнения к ним. Раздел "Supplementary reading" служит материалом для расширения словарного запаса и дальнейшего закрепления навыков работы с текстами по специальности.

Пособие может успешно использоваться как для аудиторных занятий, так и для внеаудиторной практики.

# 1. Why Curiosity Can Be Both Painful and Pleasurable

## Part 1

**Exercise I.**

Say what Russian words help to guess the meaning of the following words: anecdote, collector, chemical, demonstrate, functional, magnetic, resonance, examine, regions, mental

**Exercise II.**

Make sure you know the following words and word combinations:

To epitomize, notwithstanding, underpinning, to infer, to solidify, token, perceptual, deprivation, agreeable, to thereby

### Why Curiosity Can Be Both Painful and Pleasurable

An amusing anecdote involving Darwin epitomizes the power of curiosity in creative people. When Darwin arrived at Cambridge in 1828, he became an avid collector of beetles. Once, after stripping the bark from a dead tree, he found two beetles and caught one in each hand. At that point, he caught sight of a rare beetle. Not wanting to lose any of them, he popped one beetle in his mouth to free a hand for the rarer species. That particular adventure did not end well. The beetle in Darwin's mouth released an irritating chemical and he was forced to spit it out, apparently losing all three beetles in the process. The disappointing result notwithstanding, the story does demonstrate curiosity's irresistible appeal. But curiosity can also be an anxious and unpleasant experience. Do both states exist simultaneously in the brain? Since the early 1990s, neuroscientists have added a powerful new tool to their research arsenal, one that literally enables them to image curiosity in action in the brain. Functional magnetic resonance imaging (fMRI) is a procedure that allows researchers to examine which regions of the brain are activated during particular mental processes. The technique relies on the fact that when a certain area of the brain is used intensively, the energy required for the neural activity results in an increase in the blood flow into that region. When combined with supplementary cognitive research, fMRI offers a new dimension to the studies of curiosity. A few experiments have been particularly innovative and influential in advancing our understanding of the neurophysiological underpinnings of curiosity. (1)

Kang and colleagues used fMRI with the goal of identifying the neural pathways of curiosity. The scientists performed a test in which they scanned the brains of 19 people while these folks were presented with 40 questions. The questions, on various topics, were specially selected so as to create a diverse mixture of high and low interest in specific knowledge. One question asked, "What instrument was invented to sound like a human singing?" Another, "What is the name of the galaxy that Earth is a part of?" The participants were asked to read a question, guess the answer (if they didn't actually know it), rate their curiosity to find out the correct answer, and indicate how confident they were in their guess. In the second stage, each subject saw the question presented again, immediately followed by the correct answer. (In case you are curious, the answer to the first sample question is the violin; to the second, the Milky Way.) The reported curiosity was found to be an inverted-U-shaped function of the uncertainty. The images showed that in response to self-reported high curiosity, the brain regions that were significantly activated included areas that are known to be energized on anticipation of rewarding stimuli. This anticipation is the type of feeling you have before the curtain goes up on a play you have wanted to see for a long time. These regions had also been shown to be activated during acts of charitable donation and in reaction to punishment of unfair behavior, both of which are perceived as rewarding. The findings were therefore consistent with the idea that epistemic curiosity—that is, the hunger for knowledge—elicits anticipation of a reward state, which indicates that the acquisition of knowledge and information has value in our minds. The researchers also found that when the correct answer was revealed to the subjects, the regions of the brain that were significantly energized were those typically associated with learning, memory, and language comprehension and production. Notably, activations were found to be more powerful when the participants were shown the answers to questions for which they had previously guessed incorrectly than following correct guesses. The subjects also exhibited enhanced memory of correct answers when they had initially been wrong. A subsequent study showed that a higher curiosity in the first session correlated with better recall of surprising answers even 10 days later. This result could perhaps be expected, since the information is considered more valuable and the potential for learning is greater when a mistake is being corrected (concerning topics you are actually curious about). On the other hand, the fact that the presentation of the correct answer did not significantly activate other brain regions that are traditionally known to respond to the receipt of reward was somewhat puzzling. We should remember that there is one uncertainty that almost inevitably plagues all neuroimaging studies. While fMRI can indeed map the regions of the brain that are active when at least some form of epistemic curiosity is induced (and, as just discussed, those regions were found to be the ones that are associated with the anticipation of reward), those very same regions are also activated in a variety of other brain functions. Consequently, the inferred connection between curiosity and reward anticipation would have been rather tenuous were it not for the supporting evidence that comes from cognitive psychology. (2)

To further solidify their findings, researchers performed an additional test, crafted so as to enable a distinction between true reward anticipation and the simple function of increased attention. The new experiment had two components. In one, the researchers allowed the subjects to spend at any time one of 25 tokens to find the correct answer to one of 50 questions (10 questions were added to the original 40). Since the number of tokens equaled only half of the number of questions, the implication was that by spending a token on a particular answer, subjects were opting to give up on another. In a second condition of the experiment, subjects could decide to wait between five and 25 seconds for the answer to appear, or they could quit waiting and skip to the next question, thereby missing out on the correct answer to the preceding question. Both actions (spending a token or waiting for an answer) came at a certain cost, either of resources or of time. The results showed that spending tokens or time was strongly correlated with the expressed curiosity. This outcome considerably strengthened the interpretation of curiosity as an anticipation for reward since people are generally more inclined to invest (either time or money) in items or actions they expect to be rewarding. Overall, in spite of the remaining uncertainties, this pioneering work did suggest that specific-epistemic curiosity is linked to anticipation of information that is viewed as a reward. The additional findings, which demonstrated a strengthening of memory in response to being initially curious but wrong, indicated that curiosity enhances the potential for learning. This finding may provide important clues for improving teaching methods and for communicating information more effectively. (3)

As groundbreaking as this research was, however, it left many questions unanswered. In particular, this study explored only one kind of curiosity—specific-epistemic. Does the brain respond similarly to the stimulus of novelty, surprise, or the simple desire to avoid boredom? Does the response depend on the form of the stimulus? For example, are the processes in the brain the same when we become curious by examining an image rather than by reading a text? Another attempted to address a few of these intriguing questions. Scanning people's brains while they are being curious certainly provides for an exciting experiment. But how exactly do you ask someone to be curious? Even requesting that the participants rate their curiosity (say, on a 1–5 scale) is sure to introduce a certain amount of subjective ambiguity. Cognitive scientist Marieke Jepma of Leiden University in the Netherlands and her team used a different method from that of Kang and colleagues to pique the curiosity of her subjects. Specifically, Jepma decided to focus her attention on perceptual curiosity—the mechanism aroused by novel, surprising, or ambiguous objects or phenomena. The researchers scanned the brains of 19 participants who were shown blurred pictures of various common objects, which were difficult to identify because of the blurring. To manipulate the triggering and relief of perceptual curiosity, Jepma cleverly used different combinations of blurry and clear pictures. The subjects, therefore, never knew what to expect or whether their curiosity about the identity of the object would be relieved. Since Jepma's study was one of the very first experiments that attempted to demonstrate the neural correlates of perceptual curiosity, the results were sure to generate great interest, and they did not disappoint. First, Jepma discovered that perceptual curiosity activated brain regions that are known to be sensitive to unpleasant conditions (even though not exclusively to those). This was consistent with expectations from the information-gap theory—perceptual curiosity appeared to produce a negative feeling of need and deprivation, something akin to thirst. Second, the researchers observed that the relief of perceptual curiosity activated known reward circuits. These findings were again consistent with the idea that the termination of the distressed state by providing the desired information or at least the reduction in its intensity is perceived by the mind as rewarding. Simplistically put, being perceptually curious is a bit like being deprived, conflicted, or hungry. Satisfying one's curiosity is comparable to having good food. Jepma and her collaborators uncovered a third interesting fact: The induction and reduction of perceptual curiosity acted to enhance incidental memory (memories formed without really trying), and they were accompanied by the activation of the brain structure recognized to be associated with learning. This discovery provided additional support to the conjecture that igniting curiosity is a potent strategy not only to motivate exploration but also to strengthen learning. (4)

The differences, rather than similarities, between Jepma's results and those of Kang were particularly thought provoking. Jepma's discoveries were generally consistent with (although not a proof of) curiosity being fundamentally a disagreeable state, while the Kang findings were consistent with (but again, not a proof of) curiosity being a pleasurable condition. How can we reconcile these seemingly discrepant conclusions? First, as I have already noted, Jepma's study was designed to investigate perceptual curiosity—the curiosity stimulated by ambiguous, odd, or perplexing stimuli. Even more precisely, the curiosity mechanism evoked by blurred images can be characterized as specific-perceptual, since the participating subjects were curious to know what particular pictures represented. On the other hand, by examining the curiosity triggered by questions, Kang's study primarily explored the substrates of specific-epistemic curiosity—the intellectual desire for specific knowledge. On the face of it, therefore, the two studies seem to imply that different mechanisms of curiosity may involve (at least partially) separate regions of the brain.(5)

If confirmed, this interpretation could lend support to Jordan Litman's binary scenario. Litman proposed the existence of what he dubbed I-curiosity, the pleasurable emotion involved with interest, and D-curiosity, the aversive feeling of deprivation resulting from not having access to certain information. Combining the neuroscientific results with Litman's conception conveys the impression that perceptual curiosity should perhaps be classified principally as D-type, while epistemic curiosity is basically of the I-type. This emerging picture is also consistent with the hypothesis by cognitive scientists Jacqueline Gottlieb, that rather than using a single optimization process, curiosity is comprised of a family of mechanisms that include reactions related to novelty/surprise and measures of learning progress over longer time scales. Jepma and her colleagues cautiously noted, however, that a few uncertainties that exist in both their and Kang and her collaborators' studies do not permit one to draw definitive conclusions. For instance, because of the fact that in the Kang experiment the questions were always followed by the correct answers, it was not entirely clear whether the activation of particular brain components reflected general anticipation of feedback of some sort, curiosity about the specific correct answer, or a combination of both. This was precisely why Jepma's team sometimes chose not to relieve the uncertainty induced by the blurred images and sometimes showed a totally unrelated clear image. This deliberate differentiation allowed the researchers to separate the activation produced by curiosity about the nature of the object in the image alone from that potentially created by the anticipation of some form of feedback that would perhaps unconfound the blurred pictures. At the same time, however, Jepma's team acknowledged that the fact that in their own experiment the clear image was revealed in only half of the trials introduced an additional ambiguity into the interpretation of the results. Specifically, it was impossible to determine to what extent the participants experienced uncertainty (and thereby curiosity) about the actual identity of the image, as opposed to uncertainty about whether or not a clear image would eventually be revealed (or a mixture of the two).

These inherent limitations in the Kang and Jepma experiments serve to illustrate how difficult research in cognitive psychology and neuroscience truly is. The brain is such a complex piece of hardware and the mind such a wonderfully elaborate piece of software that even the most carefully planned experiments always leave some room for unpredictability. (6)

*Adapted from Nautilus.*

**Exercise III**.

Find paragraphs, dealing with the following: activated, flow, supplementary, underpinnings, scanned, galaxy, stimuli, donation, epistemic, enhanced

**Exercise IV**.

Fill in the gaps.

1. For many Americans cases like these …........................... the rationale for capital punishment.
2. Their sneakiness ….............................., the Senators had a strong case for a pay hike.
3. He offers practical advice, but the book has a strong philosophical …..............................
4. The parametrizations can be chosen to …............................. the same orientation on the sphere.
5. What science can see and …................................ about space and time is certainly fascinating.
6. Weak earnings reports and rising job losses are helping to …........................... that belief.

7. Learning to speaking English is a concept that is itself fraught with …...........................
8. Possess strong negotiation skills to reach optimum mutually …....................... solutions.
9. They may even want to …................................. a mediator to help them discuss the hard questions.
10. Both companies declined to …........................... on the agreement to delay their litigation.

**Exercise V.**

Make up sentences of your own with the following word combinations:

to spit out, on the face of it, to find out, to be correlated with, curious about

**Exercise VI.**

Match the words to the definitions in the column on the right:

| | |
|---|---|
| solidify | the action of anticipating something; expectation or prediction |
| elaborate | succeed in persuading or influencing (someone) to do something |
| employ | changed from the normal position by being turned upside down or being arranged in the opposite order |
| intriguing | a substance or layer that underlies something, or on which some process occurs, in particular |
| ambiguity | make or become hard or solid |

| | |
|---|---|
| to induce | a strong desire to know or learn something |
| inverted | develop or present (a theory, policy, or system) in detail |
| substrate | give work to (someone) and pay them for it |
| anticipation | arousing one's curiosity or interest; fascinating |
| curiosity | uncertainty or inexactness of meaning in language |

**Exercise VII.**

Summarize the article "Why Curiosity Can Be Both Painful and Pleasurable"

## Part 2

**Exercise I.**

Identify the part of speech the words belong to. memory, correct, initially, subsequent, curiosity, session, valuable, curious, presentation, significantly

**Exercise II.**

Form nouns from the following words: disappoint (1), demonstrate (1), functional (1), examine (1), mental (1), combined(1), innovative (1), performed (1), presented (1), create(1)

**Exercise III.**

Find synonyms to the following words. Translate them into Russian:

immediately (2), guess (2), confident (2), indicate (2), diverse (2), mixture (6), ambiguity (6), team (6), interpretation (6), results (6)

**Exercise IV.**

Find antonyms to the following words. Translate them into Russian: impossible (6), uncertainty (6), oppose (6), eventually (6), mixture (6), inherent (6), leave (6), elaborate (6), wonderfully (6), unpredictability (6)

**Exercise V.**

Match the words to make word combinations:

| | |
|---|---|
| magnetic | beetle |
| incidental | tree |
| blood | underpinnings |
| sample | memory |
| rare | research |
| dead | resonance imaging |
| avid | flow |
| cognitive | collector |
| neurophysiological | interest |
| low | question |

# 2. The herd instinct

## Part 1

**<u>Exercise I.</u>**

Say what Russian words help to guess the meaning of the following words: provocations, version, theorist, cultivated, leader, sentimental, narcissism, realist, business, partners

**<u>Exercise II.</u>**

Make sure you know the following words and word combinations:
Cultivated, goad, impelled, enlivened, to converge, to procure, remorse, compliance, nugget, susceptible

### The herd instinct

*How cultivated individuals can become barbarians in a crowd? You might wonder why many of those assembled appear so angry and full of hatred, so receptive to the provocations of a showman-in-chief goading them to expressions of intolerance and violence. What has happened to them, these otherwise friendly, engaging, law-abiding people?(1)*

Sigmund Freud wrote Group Psychology and the Analysis of the Ego (1921) with a version of this question in mind. Freud, you say? He's dead, outdated and irrelevant, critics assert, a theorist of the late-19th-century mind with little to say to our sophisticated modern selves. But I disagree – in fact, I'd argue that aspects of his work are more relevant than ever. In Group Psychology, Freud asks why crowds make a ‘barbarian’ of the ‘cultivated individual’. Why are the inhibitions enforced by social life so readily overwhelmed by all that is ‘cruel, brutal and destructive’ when we join together with others? And why does the crowd need a strong leader, a hero to whom it willingly submits? The crowd – which is, after all, just an evanescent massing of humanity, a gathering that will quickly disperse once its task is finished – is oddly ‘obedient to authority’. It might appear anarchic, but at bottom it’s conservative and tradition-bound. Freud argues that neither suggestion nor contagion – the idea that I am impelled to do what you do, to imitate you – can account for the paradoxical character of the crowd as both powerful and submissive. Rather, he proposes, it is love and all the emotional ties through which love is expressed that bind people together in a crowd. This might seem counterintuitive, in light of the crowd’s passionate anger. But it’s worth following Freud here. First, this Freudian love is no sentimental thing. It encompasses a broad range of feelings, from self-love (or narcissism) to ‘friendship and love for humanity in general’. Freud is realist enough to acknowledge that loving relations among people are often tinged with hostility. You need only consider the ‘feelings of aversion’ that exist between husband and wife, or indeed feelings that characterise other long-lasting relationships, such as between business partners, between neighbouring towns, or on a grander scale between Englishman and Scot. Love and hate are closely related. But the hostility that runs through relations among intimates pales in comparison with the aggression we direct toward strangers. There, our ‘readiness for hatred’ is everywhere evident. So, as Freud sees it, it’s all the more striking that these antipathies vanish in the crowd: ‘individuals in the group behave as though they were uniform, tolerate the peculiarities of its other members, equate themselves with them, and have no feelings of aversion towards them’. The crowd unites as it gives vent to hateful sentiments. This seems plausible to us now; hatred directed at the Other has long proven a powerful source of solidarity. But Freud also sketches a less immediately plausible scenario: members of the collective forgo the ordinary pleasures of rivalry and dislike among themselves, and instead adopt fellow-feeling and equality. The mass does this by directing its passions to the leader, an outsider whom it treats as a superior. This leader’s pull is powerful enough to neutralise the intra-group hostilities, Freud says. Conjuring up a remarkably contemporary scene, he asks us to imagine a ‘troop of women and girls’, besotted by a musician and jostling round him after a performance. Each seeks to prevail over the others, but they all know that they’re better off in renouncing their individual, rivalrous desires for the star’s love and instead uniting around their common love for him. They don’t pull out each other’s hair; each gets something of what she wants – the opportunity to pay homage to him and to feel enlivened in doing so. As at a rock concert, so in social life more generally. Identification with the leader trumps envy among individuals, knitting the group together. (2)

There’s definitely some sleight of hand here; Freud isn’t interested in how the rock star’s fans decide to stop fighting among themselves but only in the fact that they do. His account is stronger descriptively than analytically. But his notion of identification is still a powerful tool for dissecting mass behaviour. For Freud, a successful leader invites the crowd to identify with him, which in his usage involves a big dose of idealisation. Think here, Freud says, of the little boy's identification with his father – the boy wants to grow up and be like him. Identification can also be based on the perception of commonality with someone else, the sense that there's something shared between us. The leader is at once larger-than-life and familiar, bigger than I am and just like me. He's heroic and at the same time recognisably human. Today, these dynamics converge in the figure of Donald Trump. In the eyes of his supporters, he's both an idealised hero capable of extraordinary feats ('Make America Great Again!'), but also an ordinary guy just like one of them. Trump's fears and disgusts are openly on display, inviting and authorising imitation. And he is a master of playing to the crowd's desire for transcendence. First, he points to the crowd's humiliation: 'We're tired of being the patsy for, like, everybody. You have not been treated fairly.' Then he declares himself their tribune: 'At least I have a microphone where I can fight back. You people don't!' Finally, he shares his power with them, telling the crowd: 'You don't know how big you are. You don't know the power that you have.' Trump and the crowd are one; the identification is complete. (3)

We enter the text at the beginning of Chapter 7. Freud has just posed the 'pressing question' of the nature of the emotional ties among members of a group. He says these ties have been largely overlooked by group sociologists and psychoanalysts alike, arguing that they are obscure and 'hard to describe'. Here he begins by arguing that the mechanism by which these ties work is identification. Identification is known to psychoanalysis as the earliest expression of an emotional tie with another person. A little boy will exhibit a special interest in his father; he would like to grow like him and be like him, and take his place everywhere. We may say simply that he takes his father as his ideal. Identification may arise with any new perception of a common quality shared with some other person. The more important this common quality is, the more successful may this partial identification become, and it may thus represent the beginning of a new tie.We may suspect that this common quality lies in the nature of the tie with the leader.(4)

Language gives the name of 'love' to a great many kinds of emotional relationship which we too group together theoretically as love; but then again it feels a doubt whether this love is real, true, actual love, and so hints at a whole scale of possibilities within the range of the phenomena of love.Freud reminds us here that 'love' encompasses many gradations of feeling; establishing this is central to his argument that the crowd is knitted together by his newly delineated variant of love. In connection with this question of being in love we have always been struck by the phenomenon of overvaluation – the fact that the loved object enjoys a certain amount of freedom from criticism, and that all its characteristics are valued more highly than those of people who are not loved, or than its own were at a time when it itself was not loved. The illusion is produced that the object has come to be sensually loved on account of its spiritual merits, whereas on the contrary these merits may really only have been lent to it by its sensual charm. The tendency which falsifies judgment in this respect is that of *idealisation.* We are fools in love, susceptible to illusion and overestimating the qualities of the loved one. But now it is easier for us to find our bearings. It is even obvious, that the object serves as a substitute for some unattained ego ideal of our own. We love it on account of the perfections which we have striven to reach for our own ego, and which we should now like to procure in this roundabout way as a means of satisfying our narcissism. Everything that the object does and asks for is right and blameless. Conscience has no application to anything that is done for the sake of the object; in the blindness of love remorselessness is carried to the pitch of crime. From being in love to hypnosis is evidently only a short step. The respects in which the two agree are obvious. There is the same compliance, the same absence of criticism towards the loved object. There is the same sapping of the subject's own initiative. It is only that everything is even clearer and more intense in hypnosis, so that it would be more to the point to explain being in love by means of hypnosis than the other way round. The hypnotic relation is the unlimited devotion of someone in love. Hypnosis is distinguished from a group formation by this limitation of number. (5)

It might be said that the intense emotional ties which we observe in groups are quite sufficient to explain one of their characteristics – the lack of independence and initiative in their members, the similarity in the reactions of all of them, their reduction, so to speak, to the level of group individuals. But if we look at it as a whole, a group shows us more than this. Some of its features – the weakness of intellectual ability, the lack of emotional restraint, the inclination to exceed every limit in the expression of emotion and to work it off completely in the form of action – these features show an unmistakable picture of a regression of mental activity to an earlier stage such as we are not surprised to find among savages or children. We thus have an impression of a state in which an individual's private emotional impulses and intellectual acts are too weak and are entirely dependent on being reinforced by being repeated in a similar way in the other members of the group. We are reminded of how many of these phenomena of dependence are part of the normal constitution of human society, of how little originality and personal courage are to be found in it, of how much every individual is ruled by those attitudes of the group mind which exhibit themselves in such forms as racial characteristics, class prejudices, public opinion, etc. Identification among members of the massed crowd is not spontaneous. Rather, it's catalysed by the leader, who is powerful enough to elicit and then embody everyone's dreams and aspirations – their ego ideals. The recognition of sameness is refracted through the force of the leader's personality. (6)

It is naturally no easy matter to trace the ontogenesis of the herd instinct. Freud shows us just how familiar the mechanism of group formation is in day-to-day life. Many of us have observed it in the way an older sibling's jealousy can be abandoned and transformed into communal feeling. Another nugget of Freudian wisdom – just how alert we are to competitive advantage and how willing we are to punish offenders of group norms. If we can't play with a toy, better to smash it than let anyone else have it. We demand equality not because we're socially minded but because it's the price we pay to ensure that neither our friends nor our enemies will get more than we have. Questions remain, especially about the allure of the leader. We see what the group gets from the leader, but what does the leader get from the group? He works the crowd but appears not to 'need' it; manifestly the selfless servant of the masses, his craving for adulation is disguised. But what if the leader's neediness is openly on display? 'This is like medicine for him,' said one Trump supporter at a recent gathering. Yet another observed of Trump that 'he connects with the average American … He's just a man.' We might speculate that the identification tying together leader and led is all the more intense here, premised on a felt commonality of flawed, needy humanity. (7)

*Adapted from Aeon*

**Exercise III.**

Find paragraphs, dealing with the following: evident, antipathies, hateful, solidarity, forgo, troop, rivalrous, homage, trumps

**Exercise IV.**

Fill in the gaps.

1. An audience loves rooting for an underdog, but what about a …...................... underdog?
2. Creating reasonable motives for unreasonable people only serves to …......................... them on.
3. Some say the visit and the president's stance show an …................................. for corruption.
4. Dismissing Facebook as ….............................. to business would be dangerously shortsighted.
5. A lot of this work is ...................................... and requires a willingness to experiment.
6. This readable modern history is …................................ by illustrations from ad campaigns.
7. Indeed, the interests of Russia and the West could, in some respects, …............................................
8. Their whole business model involves trying to …............................ those two key facts above.

9. These platforms also slash IT costs, ………………………. expenses, and development costs.
10. You can name an object and point to the image to ……………………………. language development.

**Exercise V**.

Make up sentences of your own with the following word combinations:

to conjure up, larger than life, to pull out, to knit together, no easy matter

**Exercise VI**.

Match the words to the definitions in the column on the right:

| | |
|---|---|
| sleight | a measure or condition that keeps someone or something under control or within limits |
| to reinforce | push, elbow, or bump against (someone) roughly, typically in a crowd |
| obscure | charming and attractive |
| to vanish | grant to (someone) the use of (something) on the understanding that it shall be returned |
| to disperse | the use of dexterity or cunning, esp. so as to deceive |
| barbarian | strengthen or support, esp. with additional personnel or material |
| to lend | not discovered or known about; uncertain |

| | |
|---|---|
| engaging | disappear suddenly and completely |
| to jostle | distribute or spread over a wide area |
| restraint | a member of a community or tribe not belonging to one of the great civilizations (Greek, Roman, Christian) |

**ExerciseVII.**

Summarize the article "The herd instinct".

## Part 2

**Exercise I.**

Identify the part of speech the words belong to.

intolerance, irrelevant, contagion, counterintuitive, aversion, plausible, identification, provocations, expressions, intolerance

**Exercise II .**

Form verbs from the following words:

expressions (1), identification (1), connection (1), application (2), limitation (2), reduction (2), inclination (2), completely (2), recognition (2), supporter (2)

**Exercise III.**

Find synonyms to the following words. Translate them into Russian:

round (1), leader (7), enemy (7), demand (7), norm (7), offender (7), punish (7), feeling (7), display (7), identification (7)

**<u>Exercise IV.</u>**

Find antonyms to the following words. Translate them into Russian: disguise (7), servant (7), competitive (7), advantage (7), wisdom (7), communal (7), transforme (7), jealousy (7), leader (7), formation (7)

**<u>Exercise V.</u>**

Match the words to make word combinations:

| | |
|---|---|
| neighbouring | scale |
| plausible | anger |
| strong | scenario |
| business | people |
| long-lasting | towns |
| passionate | instinct |
| emotional | partners |
| law-abiding | relationships |
| herd | leader |
| grander | ties |

# 3. To Be More Creative, Cheer Up

## Part 1

**Exercise I.**

Say what Russian words help to guess the meaning of the following words: muscle, industrial, economy, innovation, absolute, published, tactics, process, impulsive, conformist

**Exercise II.**

Make sure you know the following words and word combinations.
to upend, disagreeableness, prickly, shortcut, to meander, illumination, DMN, divergent, convergent, subliminal

### To Be More Creative, Cheer Up

*Is creativity a skill I can beef up like a weak muscle?*

Absolutely, says Mark Runco, a cognitive psychologist who studies creativity at the University of Georgia. “Everybody has creative potential, and most of us have quite a bit of room for growth,” he says. “That doesn’t mean anybody can be Picasso or Einstein, but it does mean we can all learn to be more creative.” After all, creativity may be the key to Homo sapiens’ success. Our species is not fast. We’re not terribly strong. What we do have is the ability to imagine and create new possibilities. Creativity is certainly a buzzword these days. Amazon lists more than 6,000 self-help titles devoted to the subject. A handful of universities now offer master’s degrees in creativity, and a growing number of schools offer an undergraduate minor in creative thinking. We’ve moved beyond the industrial economy and the knowledge economy. We’re now in the innovation economy. Creativity is a necessary skill to be successful in the work world. It's not a luxury anymore to be creative. It's an absolute necessity. But can you really teach yourself to be creative? A study published in the Creativity Research Journal reviewed 70 studies and concluded that creativity training is effective. But it wasn't entirely clear how it worked, or which tactics were most effective. Recent studies, however, take us inside the brain to tap the source of our creative juices, and in the process upend longstanding myths about what it takes to be Hemingway or Picasso. Some of the earliest scientific studies of creativity focused on personality. And some evidence suggests that innovation comes easier to people with certain personality types. A review of dozens of creativity studies found that overall, creative people tend to be more impulsive and self-confident. Above all, though, two personality traits tend to show up again and again among innovative thinkers. Unsurprisingly, openness to new ideas is one. The other? Disagreeableness. Highly creative people tend to run counter to the popular ways of doing things. Think of Steve Jobs—a prickly personality to say the least. (1)

Yet fortunately for me and my conformist counterparts researchers have come around to thinking about creativity not as a personality type, but as a cognitive process. Creativity can be thought of as a particular kind of problem solving. It's a way of thinking that's applied to open-ended problems where there isn't an off-the-shelf answer. If creativity is a cognitive process, we should be able to learn to do it better. For decades, creativity researchers have generally thought of the process in terms of four basic steps. Step one is preparation. Painters need to understand something about color and form; composers have to know how to read music. Sorry, no shortcuts. After preparation comes incubation. During this step, ideas meander through your brain's neural networks, bumping into other ideas to combine in interesting ways. When the right ideas collide, you experience step three: illumination. This is the light bulb coming on, the fabled Aha! moment. The fourth and final step is verification. This is creativity's logical bit—the critical thinking component in which you figure out if the idea has legs. Each step requires a complex set of cognitive abilities. In fact, creativity draws on so many different skills that it can be hard for researchers to know where to start. "As we home in on the different cognitive systems that are involved in different aspects of creativity, it pulls in more and more systems until eventually the whole brain is involved," Jung says. That in itself is an intriguing finding. For one thing, it contradicts the popular (but erroneous) belief that creativity is a right-brained endeavor, while the left side is supposedly in charge of analytical thinking and rule-based processes like language. "Certainly you'll see regions in the right hemisphere that are associated with creativity, but just as often, if not more often, you'll see regions in the left," says Jung. (2)

So far, much of the scientific research of creativity seems to have focused on the idea-floating incubation stage of the process. Research from Jung's lab and others suggests that incubation relies strongly on a neural pathway known as the default mode network (DMN). This neural network is most active when we're not concentrating our attention on a task. During these idle moments the DMN gets to work, scanning our surroundings for the details of the environment. But the DMN doesn't just turn our attention outward. It's also the part of the brain involved in self-reflection. "That's the part of your brain that you use when you're thinking about yourself, your relationships, how you'd handle a certain situation," Jung says. "It's daydreaming." But creativity is more than just staring at the clouds. During creative thinking, there's a push-and-pull between the default mode network and another pathway called the cognitive control network (CCN). This is the network most active during so-called executive functions such as planning, reasoning, and problem solving. The DMN and CCN aren't exactly in opposition with one another, however. There's an intersection between them, a back-and-forth. It's a dance between internal and external cognitive networks as you bring a new idea into being. The first step in that dance is often a process called divergent thinking—the hallmark of incubation. Think of it as tuning out, or letting your consciousness go fuzzy. Distancing yourself from a creative challenge allows your thoughts to travel down new neural pathways, allowing for new connections and fresh ideas. You're casting a very wide net to find an insight or a way forward. Multiple studies have found that divergent thinking is a strong predictor of one's creative achievement—better even than IQ. And happily for researchers, divergent thinking can be assessed fairly easily using behavioral measures in the lab, making it a useful metric of creative potential. (A common test of divergent thinking: In two minutes, list all the uses you can think of for a common household object like a toothpick, then determine how many are original or surprising.) For someone looking for a creativity boost, divergent thinking is the place to start. The trick is learning to deliberately manage your own thinking. All humans are able to engage in both divergent and convergent (or analytical) thinking, but we often don't do that in a very efficient way. For an example of mental efficiency, consider Ernest Hemingway. When he got up in the morning he would do free writing with a pencil, capturing all of his thoughts. He wouldn't use punctuation. There would be half thoughts. Once he had enough material, then he would shift to his typewriter and start to synthesize. (3)

Luckily, there are almost endless ways to practice divergent thinking, Jung tells me. There's often some trial-and-error involved as people figure out what works for them. "Most creative people have figured out a way to do the incubation thing—whether it's meditation or staring out the window or taking long walks so their ideas can percolate," Jung says. "It's finding that magic space where you're not actively engaged with the external world, and not just surfing the Internet." In a review of more than three dozen studies of incubation, researchers from Lancaster University found that setting aside a problem was helpful for improving performance on divergent thinking tasks. Yet some methods may be better than others, they discovered. The trick appears to be engaging your mind, but just a little bit. The researchers found tasks that required a low mental investment, like reading, were most beneficial to the problem-solving process. Mentally demanding tasks like counting backward were less helpful—and surprisingly, plain old rest was also less effective at boosting divergent thinking. Of course, there's more to creativity than divergent thinking. The first and fourth steps of the creative process—preparation and verification—are fairly straightforward. But many would argue that the third step—illumination—is where the magic happens. And scientists are just starting to consider the Aha! moment from a neurological point of view. Mark Beeman, a neuroscientist at Northwestern University, focuses on the science of insight, often in collaboration with John Kounios, a cognitive scientist at Drexel University. They've found different patterns of brain activity when people solved problems using insight versus problems solved analytically. Interestingly, those patterns appeared milliseconds before the problem was ever presented. In other words, some brains appeared to be primed for insight. The obvious question, then: How do you prepare your mind for a stroke of genius? One important element, Beeman says, is to maintain a loose state of attention rather than focus intently on a problem. This goes hand in hand with divergent thinking. "Incubation and insight are highly related," he says. "You've been working on a problem, you set it aside and boom! It comes to you." Some people have naturally leaky attention filters, he adds. But the concentrators among us can take steps to maximize the potential for insight. For one thing, it helps to have a sunny outlook. Beeman and his colleagues found that people are more likely to maintain broader attention and solve problems when they're in a positive mood. "The basic idea is that a positive mood loosens the grip of attention, so that stimuli and ideas that used to get filtered out can now have a greater impact on mental processing," he says. "Stress and anxiety have the opposite effect, narrowing attention, which can be good for focused analytic thinking—as long as you keep focus on the right information—but bad for broader creative thinking." Beeman's team has also found evidence that you can actively change your attention state. He flashed images (of sheep, for example) in front of volunteers, too quickly for them to consciously recognize what they'd seen. But with practice, they began to trust their intuitions and somehow tap into the weak associations—wool? farm?—that bubbled up in the moments after the picture flashed before their eyes. They got better at identifying the images, and as they did, they solved more problems with insight. Subliminal messages obviously aren't easy to replicate at home. But stay tuned. "I'm pretty convinced that what we're studying in the lab is relevant for real-world creativity," he says.(4)

Meanwhile, we can take cues from more fundamental findings from the world of creativity research. Robert Bilder, director of the Center for the Biology of Creativity at the University of California, is trying to work out creativity's basic biochemistry. He's focusing on three broad cognitive abilities he believes are crucial to creative achievement: the ability to generate novel ideas; response inhibition, or the ability to shake off old habits and break out of a routine; and working memory, the skill that allows people to hold disconnected ideas in the conscious mind long enough to use them. All three are complex abilities that can't easily be pinpointed to specific regions of the brain, Bilder says. Instead, he's exploring the thickets of brain networks that allow us to engage in these processes, and the genes that code for them. He's also studying molecular expression to figure out how and when the responsible genes are switched on and off. It's an ambitious project. "The genetic underpinnings are so complex, we can estimate there may be upward of 10,000 genes involved in a particular trait," he says. Despite the challenge, Bilder says we can already begin to draw some practical conclusions from these efforts. Consider the finding that inhibition is necessary for creativity. "Many people think being uninhibited is the most important thing," he says. But it's critical to inhibit habits that prevent us from realizing our creative potential—like my tendency to shoot down ideas before they're fully formed. Working memory is also an obvious target for self-improvement. Some research suggests that working memory is a skill that can be improved with systematic training. But we'd also do well to recognize our limits. "Many people probably attempt to keep things in working memory when it's not realistic to do so," Bilder says. "People beat themselves up trying to do things that aren't neurophysiologically possible." Bilder offers up one last bit of practical advice: Just get your ideas out there—on paper, on canvas, out of your head. "If you get that thought or product out there, it frees you up to go onto the next idea," he says. In fact, creative output is one of the best predictors of creative success. For all the one-hit-wonders, there are many more examples of creators who generated a huge body of work. "Picasso created somewhere between 10,000 and 50,000 works during his life," Bilder says. "Don't worry about whether your idea is good enough. Once it's out there, then you can say, 'oh that was terrible'—and keep going." Hemingway may have been famous for his brevity, but he wrote 47 different endings to "A Farewell to Arms". Come up with enough ideas, and a good one is sure to stick. Creativity, in other words, is a slog. I can keep waiting around for the Aha! moment. Or I can get to work. (5)

*Adapted from Nautilus*



**Exercise III**.

Find paragraphs, dealing with the following: off-the-shelf, painters, shortcuts, incubation, collide, bulb, verification, logical, endeavor, self-reflection.

**Exercise IV**.

Fill in the gaps.

1. She never liked to acknowledge, let alone confront, …...................... within her family.
2. None of the movies is groundbreaking, but Neil LaBute's two …........................... expectations.
3. Most of these …........................ redirects are just abbreviated forms of the page's title.
4. It will …......................... along for another few years before there is any determination.
5. Include your telephone number, municipality and return address for …........................
6. However, it has been suggested that every event precipitates a …........................... future.
7. It offers …........................... to a person's likes and interests and maybe even their quirks.
8. …........................ means that the effect functions below the threshold of consciousness.
9. Logical, organized and …..............................., he loved figuring out how things worked.
10. Like a lot of people, I'll let those pictures lay …............................ on my handset for months.

**Exercise V**.

Make up sentences of your own with the following word combinations:

to beef up, to home in on, push and pull, to tune out, to slog at, in other words, to stare out the window, to take long walks

**Exercise VI .**

Match the words to the definitions in the column on the right:

| | |
|---|---|
| cognitive | to form or have a mental picture or idea of something |
| minor | not working or being used |
| verification | the ability to produce original and u nusual ideas, or to make something new or imaginative |
| straightforward | someone who studies the human mind and hu man emotions and behaviour, and how different situations have an effect on people |
| idle | |
| insight | lesser in importance, seriousness, or significance |
| creativity | the process of establishing the truth, accuracy, or validity of something |
| innovation | uncomplicated and easy to do or un- derstand |
| psychologist | connected with thinking or conscio us mental processes |
| imagine | (the use of) a new idea or method |

**Exercise VII.**

Summarize the article “To Be More Creative, Cheer Up ”

## Part 2

**Exercise I.**

Identify the part of speech the words belong to.

certain, situation, cognitive, control, exactly, opposition, intersection, internal, external

**Exercise II.**

Form adjectives from the following words: absolutely (1), potential (1), necessity (1), entirely (1), personality (1), openness (1), fortunately (1), generally (1), strongly (1), attention (1)

**Exercise III.**

Find synonyms to the following words. Translate them into Russian: straightforward (3), divergent (3), manage (3), determine (3), original (3), common (3), multiple (3), internal (3), turn (5), terrible (5)

**Exercise IV.**

Find antonyms to the following words. Translate them into Russian: systematic (3), realistic (3), huge (3), part (3), improve (5), skill (5), memory (5), famous (5), active (5), default (5)

**Exercise V.**

Match the words to make word combinations:

| | |
|---|---|
| open-ended | degrees |
| working | thinking |
| Research | solving |
| personality | memory |

| | |
|---|---|
| problem | Journal |
| cognitive | Myths |
| creative | problems |
| master’s | traits |
| weak | psychologist |
| longstanding | muscle |

# 4. Science is broken

## Part 1

**Exercise I.**

Say what Russian words help to guess the meaning of the following words: civilization, condition, symbiotic, risk, segments, faculty, positions, dollars, reform, balance

**Exercise II.**

Make sure you know the following words and word combination

Laureat, adversely, STEM, to mine, h-index, quadruple, superficially, to compel, nonetheless, susceptible, allocation,

### Science is broken

*Perverse incentives and the misuse of quantitative metrics have undermined the integrity of scientific research(1)*

The rise of the 20th-century research university stands as one of the great achievements of human civilisation – it helped to establish science as a public good, and advanced the human condition through training, discovery and innovation. But if the practice of science should ever undermine the trust and symbiotic relationship with society that allowed both to flourish, our ability to solve critical problems facing humankind and civilisation itself will be at risk. We recently explored how increasingly perverse incentives and the academic business model might be adversely affecting scientific practices, and by extension, whether a loss of support for science in some segments of society might be more attributable to what science is doing to itself, as opposed what others are doing to science. We argue that over the past half-century, the incentives and reward structure of science have changed, creating a hypercompetition among academic researchers. Part-time and adjunct faculty now make up 76% of the academic labour force, allowing universities to operate more like businesses, making tenure positions much more rare and desirable. Increased reliance on emerging quantitative performance metrics that value numbers of papers, citations and research dollars raised has decreased the emphasis on socially relevant outcomes and quality. There is also concern that these pressures could encourage unethical conduct by scientists and the next generation of STEM scholars who persist in this hypercompetitive environment. We believe that reform is needed to bring balance back to the academy and to the social contract between science and society, to ensure the future role of science as a public good. (2)

The pursuit of tenure traditionally influences almost all decisions, priorities and activities of young faculty at research universities. Recent changes in academia, however, including increased emphasis on quantitative performance metrics, harsh competition for static or reduced federal funding, and implementation of private business models at public and private universities are producing undesirable outcomes and unintended consequences. Quantitative metrics are increasingly dominating decision-making in faculty hiring, promotion and tenure, awards and funding, and creating an intense focus on publication count, citations, combined citation-publication counts, journal impact factors, total research dollars and total patents. All these measures are subject to manipulation as per Goodhart's law, which states: When a measure becomes a target, it ceases to be a good measure. The quantitative metrics can therefore be misleading and ultimately counterproductive to assessing scientific research. The increased reliance on quantitative metrics might create inequities and outcomes worse than the systems they replaced. Most scientists think that the damage owing to metrics is already apparent. In fact, 71% of researchers believe that it is possible to 'game' or 'cheat' their way into better evaluations at their institutions. This manipulation of the evaluative metrics has been documented. Recent exposes have revealed schemes by researchers to mine for statistically significant and publishable results, rigging of the peer-review process itself and over-citation practices. The computer scientist Cyril Labbé at the Joseph Fourier University even created Ike Antkare, a fictional character, who, by virtue of publishing 102 computer-generated fake papers, achieved a stellar h-index of 94 on Google Scholar, surpassing that of Albert Einstein. Blogs describing how to inflate your h-index without committing outright fraud are, in fact, just a Google search away. Since the Second World War, scientific output as measured by cited work has doubled every nine years. How much of the growth in this knowledge industry is, in essence, illusory and a natural consequence of Goodhart's law? It is a real question. Consider the role of quality versus quantity maximising true scientific progress. If a process is overcommitted to quality over quantity, accepted practices might require triple- or quadruple-blinded studies, mandatory replication of results by independent parties, and peer review of all data and statistics before publication. Such a system would produce very few results due to over-caution, and would waste scarce research funding. At another extreme, an overemphasis on quantity would produce numerous substandard papers with lax experimental design, little or no replication, scant quality control and substandard peer-review. As measured by the quantitative metrics, apparent scientific progress would explode, but too many results would be erroneous, and consumers of research would be mired in wondering what was valid or invalid. Such a system merely creates an illusion of scientific progress. Obviously, a balance between quantity and quality is desirable. It is hypothetically possible that in an environment without quantitative metrics and fewer perverse incentives emphasising quantity over quality, practices of scholarly evaluation (enforced by peer review) would evolve to be near to an optimum level of productivity. But we suspect that the existing perverse-incentive environment is pushing researchers to overemphasise quantity in order to compete, leaving true scientific productivity at less than optimal levels. If the hypercompetitive environment also increased the likelihood and frequency of unethical behaviour, the entire scientific enterprise would be eventually cast into doubt. While there is virtually no research exploring the precise impact of perverse incentives on scientific productivity, most in the academic world would acknowledge a shift towards quantity in research. Favouring output over outcomes, or quantity over quality, can also create a ‘perversion of natural selection’. Such a system is more likely to weed out ethical researchers, while selecting for those who better respond to perverse incentives. The average scholar can be pressured to engage in unethical practices in order to have or maintain a career. Then unethical actions become embedded in the structures and processes of a professional culture. Nowadays even senior researchers provide perfectly rational explanations for leaving their privileged and prized positions, rather than compromise their principles in a hypercompetitive, perverse-incentive environment. In brief, although quantitative metrics provide a superficially attractive approach to evaluating research productivity in comparison with subjective measures, once they are a target they cease to be useful and can even be counter-productive. Continued overemphasis of quantitative metrics might compel all but the most ethical scientists to produce more work of lower quality, to 'cut corners' whenever possible, decrease true productivity, and select for scientists who persist and thrive in a perverse-incentive environment. (3)

Many scientific societies, research institutions, academic journals and individuals have advanced arguments trying to correct some excesses of quantitative metrics. Some have signed the San Francisco Declaration on Research Assessment (DORA). DORA recognises the need for improving 'ways in which output of scientific research are evaluated', and calls for challenging research-assessment practices, especially the currently operative 'journal impact factor' parameters. The American Society of Microbiology recently took a principled stand and eliminated impact-factor information from all their journals 'to avoid contributing further to the inappropriate focus on journal impact factors'. The aim is to slow the 'avalanche' of unreliable performance metrics dominating research assessment. Like others, we are not advocating for the abandonment of metrics, but reducing their importance in decision-making by institutions and funding agencies, until we possibly have objective measures that better represent the true value of scientific research. Colleges and universities have historically served to shape the next generation of researchers, who will provide education and knowledge for and to the public. But as universities morph into 'profit centres' focused on generating new products and patents, they are de-emphasising science as a public good. Competition among researchers for funding has never been more intense, entering an era with the worst funding environment in half a century. Nonetheless, the grant environment is hypercompetitive, susceptible to reviewer biases and strongly dependent on prior success as measured by quantitative metrics. Even before the financial crisis struck, the Nobel laureate Roger Kornberg remarked: 'If the work you propose to do isn't virtually certain of success, then it won't be funded.' These broad changes take valuable time and resources away from scientific discovery and translation, compelling researchers to spend inordinate amounts of time constantly chasing grant proposals and filling out ever increasing paperwork for grant compliance. The steady growth of perverse incentives, and their instrumental role in faculty research, hiring and promotion practices, amounts to a systemic dysfunction endangering scientific integrity. There is growing evidence that today's research publications too frequently suffer from lack of replicability, rely on biased data-sets, apply low or sub-standard statistical methods, fail to guard against researcher biases, and overhype their findings. In other words, there is an overemphasis on quantity versus quality. It undermines the credibility of the scientific community and everyone in it and strongly suggests that modern science is untrustworthy and in need of reform. Given the high cost of exposing, disclosing or acknowledging scientific misconduct, we can be fairly certain that there is much more than has been revealed. (4)

The principle of self-government in academia is strong, and this is a distinguishing feature of the modern research university.

Science is expected to be self-correcting. We have come to believe, however, that incentives throughout the system induce all stakeholders to ‘pretend misconduct does not happen’. It is remarkable that science never developed a clear system for reporting and investigating allegations of research misconduct. Individuals who do allege misconduct don’t have an easy, evident path to do so, and risk suffering severe negative professional repercussions. In relation to what is considered fair in reporting research, grant-writing practices and promoting research ideas, scholars operate, to a great extent, on an unwritten honour system. Today, there are compelling reasons to doubt that science as a whole is self-correcting. Scientists have proposed open-data, open-access, post-publication peer review and efforts to reproduce landmark studies as practices to help compensate for the high error rates in modern science. Beneficial as these corrective measures might be, perverse incentives on individuals and institutions remain the root problem. Generally, however the limitations of hot research sectors are downplayed or ignored. Because every modern scientific mania creates a quantitative metric windfall for participants, and because few consequences come to those responsible when a science bubble bursts, effective check and misallocation of resources is the unwritten honour system. If we don’t reform the academic scientific-research enterprise, we risk public distrust of science. The modern academic research enterprise operates on a system of perverse incentives that would have been almost inconceivable to researchers 50 years ago. We believe that this system presents a real threat to the future of science. If immediate action is not taken, we risk creating a corrupt professional culture. All scientists should aspire to leave the field in a better state than when we first entered it. The very important matters of state and federal funding lie beyond our direct control. However, when it comes to the health, integrity and public perception of science and its value, we are the key actors. We can openly acknowledge and address problems with perverse incentives and hypercompetition that are distorting science and imperilling scientific research as a public good. We can no longer afford to pretend that the problem of research misconduct does not exist. Universities can take measures immediately to protect the integrity of scientific research, and announce steps to reduce perverse incentives and uphold research misconduct policies that discourage unethical behaviour. Finally, and perhaps most simply, in addition to teaching technical skills, PhD programmes themselves should accept that they ought to acknowledge the present reality of perverse incentives, while also fostering character development, and respect for science as a public good, and the critical role of quality science to the future of humankind. At both the undergraduate and graduate levels, science and engineering students should receive realistic instruction on these subjects, so that they are prepared to act when, not if, they encounter it. (5)

*Adapted from Aeon.*

**Exercise III**.

Find paragraphs, dealing with the following: pursuit, academia, harsh , awards, target, counterproductive, exposes, fictional, blogs, illusory

**Exercise IV**.

Fill in the gaps.

1. What happened to my family ………………………. affected my whole childhood and later life.
2. I decided the pain was ……………………… to a shoe that needed a little breaking in.
3. Rumors …………………….. that somehow, in some way, the Hartleys themselves were involved.
4. Too often promising moves broke down through poor execution and …………………… errors.
5. As a result, his mature plays are ……………………… similar to television sitcoms.
6. Life in any ad agency consists of creating messages that …………………… consumers to buy.
7. ……………………, this was not a deal that shareholders had pushed for, nor expected.
8. India's growth is thus less ………………………. to shocks from the international economy.
9. So there will be a final …………………….. of 25 tickets going online tomorrow at 11am.
10. It is not all that …………………….. for Google to make this kind of miscalculation.

**<u>Exercise V</u>.**

Make up sentences of your own with the following word combinations: by virtue, at risk, to weed out, to engage in, at the undergraduate, at the graduate levels, in brief

**<u>Exercise VI</u>.**

Match the words to the definitions in the column on the right:

| | |
|---|---|
| disclose | a set of numbers that |

| | |
|---|---|
| | give information about a particular process or activity |
| landmark | a thing that motivates or encourages one to do something |
| to persist | to force somebody to do something, or to make sure that something happens |
| attributable | make (secret or new information) known |
| inconceivable | a person or group of people who own a share in a business |
| inordinate | a building or place that is easily recognized, especially one that you can use to judge where you are |
| metrics | to try to do or continue doing something in a determined but often unreasonable way |
| stakeholder | capable of being attributed |
| enforce | not capable of being imagined or grasped mentally; unbelievable |
| incentive | unusually or disproportionately large; excessive |

**Exercise VII.**

Summarize the article "Science is broken".

## Part 2

**Exercise I.**

Identify the part of speech the words belong to.
consequence, real , question, consider, mandatory, replication, independent, statistics, publication, invalid.

**Exercise II .**

Form adverbs from the following words:
critical (1), rare (1), relevant (1), consequences (1), real (1), extreme (1), apparent (1), frequency (1), entire (1), doubt (1)

**Exercise III.**

Find synonyms to the following words. Translate them into Russian: virtually (3), maintain (3), senior (3), provide (3), compromise (3), productivity (3), comparison (3), parameter (3), instruction (5), prepare(5)

**Exercise IV.**

Find antonyms to the following words. Translate them into Russian:
unethical (3), cease (3), excesses (3), respect (5), present (5), direct (5), inconceivable (5), evident (5), severe (5), professional (5)

**Exercise V.**

Match the words to make word combinations:

| | |
|---|---|
| hypercompetitive | faculty |
| tenure | good |
| adjunct | environment |
| scientific | positions |
| critical | faculty |
| symbiotic | metrics |
| public | practices |
| human | problems |
| quantitative | relationship |
| young | civilisation |

# SUPPLEMENTARY READING

## The Art of Teaching Math and Science

*The impasse in math and science instruction runs deeper than test scores or the latest educational theory. What can we learn from the best teachers on the front lines?*

Time. Pencils down. As a nation, we've sweated over tests, dissected underperforming schools, gutted standards and curricula, and rinsed and repeated. We've thrown the classroom desk-chair at the problem and still earn no better than a C-minus when it comes to math and science literacy. No test is perfect, but according to the 2012 Program for International Student Assessment, 15-year-old Americans ranked 27th in math and 20th in science out of 34 member countries of the Organization for Economic Cooperation and Development. (December 6 update: In the 2015 assessment released today, the United States ranked 19th in science and 31st in math out of 35 OECD countries.)

The puzzle persists in a superposition of states: Are standards too low or — provocatively — too high? How do we adequately and equitably fund schools? Are we teaching the right stuff, in the right order? Or is it more about the process of inquiry? Do standardized tests help anyone besides the testing industry? Are traditional classrooms conducive to learning? Should we add technology or subtract it? These issues demand attention. But one variable that's too often lost amid public hand wringing over test scores and new standards is arguably the most vital: the fallible humans charged with imparting an appetite and appreciation for learning. To shine a spotlight on this linchpin of America's byzantine education system, Quanta Magazine followed four master science and math teachers into their classrooms. Here are their stories.

**TRY**

Early in the morning on Monday, May 23, the uptown 5 train lurches skyward from its subterranean shaft, rising into the light of the Bronx. The cars groan as they lumber over elevated tracks high above the avenues, bodegas and detached homes, alongside treetops and the Escher-esque maze of rusty low-rise fire escapes. Twelve stops later, just shy of the end of the line, the few remaining riders wander out onto Baychester Avenue. Up the hill sits a squat, checker-patterned building with a triangle-wave marquee that is home to Baychester Middle School. The bell blares. Upstairs in the "Cornell University" homeroom, so named to get kids thinking early and often about college, Channa Comer addresses her students with a big voice and an even bigger Cheshire cat smile: “Cornell, 10 seconds to take out your homework, 10, 9, 8 … ” The students scramble, rifling through their backpacks, until they are all seated at their desks with their notebooks in front of them. They all wear blue school-issued shirts with big white letters across their backs. Over the course of the year, they earn shirts with letters that spell TRUST, TRAIN or THANK. Today the shirts say TRY.

All around them are reminders to try, including posters that advise: “Life is complicated: Let’s deal with it,” and “Think like a proton and be positive.” In front of the classroom, printed above a whiteboard with the day’s schedule, are vocabulary words like “parameter,” “syntax” and “data type,” along with their definitions. A shelf at the back of the room holds clear containers packed with pine cones and shells. Below are containers for compost, soil, plants, rocks, starfish and safety goggles. Standing 5 feet 1 in two-inch-high platform sandals, Comer projects an outsize presence. Her voice easily fills the room, but she rarely raises it, except to let loose a mammoth laugh or to sing the praises of a student — today it’s Shawnay — who got 100 on her scorecard for good behavior. Comer has an athletic build that comes from years of martial arts and marathon training, not to mention amateur competitive bodybuilding, activities that have taken a toll on her now bandaged 40-something-year-old knees. A naturally inquisitive serial career changer, Comer took advanced biology courses as a nursing student, studied some physics and engineering for a job coordinating the construction of group homes, and, after becoming a teacher, spent several summer vacations conducting scientific field research. “There’s nothing that has no relationship to science,” Comer said after the class. “It’s very important to me that students know how the world around them functions.”

But learning science is like learning another language, she said, and only 10 percent of Baychester’s students read English at or above grade level. Complicating matters, elementary school teachers vary widely in their interest or ability to teach science. By the time kids arrive in Comer’s sixth-grade class, some have had virtually no science, some have only read textbooks, while others have been doing full-on experiments. Even at the middle school level, she said, “science is not a priority because of testing. The high stakes of math and language arts, that’s what kids get promoted based on and what teachers get rated based on.” Complicating matters further, the school sits opposite the borough’s largest public housing complex, with 42 buildings, 2,000 apartments and a history of gang violence. Comer uses anything and everything, including videos, songs (she has students clap and chant: “S-C-I-E-N-C-E, scientists is what we’ll be! Solve. Create. Investigate. Evaluate. Notice. Classify.

Experiment!"), kinesthetic learning (on this morning, she calls students up to act out how molecules behave), physical models (students roll little balls of Play-Doh to model molecular characteristics) and analytical reading to "ensure that every kid gets some point of access based on their level." Throughout her lessons she interrogates students with reflexive urgency: "What's your evidence? I need to know," followed by the kicker, "How do you know?" Then come hands-on experiments to reinforce meaning and evoke wonder.

But when she started her teaching career in 2007, at a small Bronx high school called Urban Assembly Academy of History and Citizenship for Young Men that has since closed, on many an evening Comer curled into a fetal position on her bed, crying. "I was jumping through hoops, standing on my head, trying to get kids interested," she said. "Every day I get home and I felt like I just did battle." She remembers starting a unit on the human body, thinking, "Everyone wants to know about their bodies." She was blindsided when a student said, "Ah, miss, I don't care how it works as long as it works." She knew she needed to drop to a lower grade where she could get kids excited about science. At the sixth-grade level, Comer said, "I'm not concerned that students remember everything or can regurgitate information. I feel that if they really have a level of engagement, they'll learn all the nuts and bolts." After four years at the high school level, Comer became the founding sixth-grade science teacher at Baychester. Shawn Mangar, the school's founding principal, said that soon after Comer was hired, she showed up in a U-Haul loaded with science materials she had purchased over the years, eliciting an "Are you serious?" from security staff. And last year, she took the popular rap song that all the kids were singing — "Trap Queen" by Fetty Wap, about a guy teaching his girlfriend how to make crack cocaine — found the background music and organized a competition for students to rewrite the lyrics with science content. The winning students performed their remake — about the water cycle — at the Science Genius competition at Columbia University. Comer also started an after-school engineering club with funding from the SECME consortium of universities and later received a $2,500 Summer of Innovation grant from NASA to purchase supplies for it. "Those kinds of things she makes happen," Mangar said.

Comer is also known for her dogged insistence that students solve their own problems. Too often, said Vice Principal Elizabeth Leebens, students "get the history of science rather than getting an opportunity to do it for themselves." Still, Leebens was surprised when, after a group of science club students asked Comer for help with their ice-cream-making experiment, which had already failed seven sticky times, Comer told them, "Go back and check your process." Off they went to the bathroom to dump the latest batch and start over. "I call it productive struggle," Comer said. "That's where the growth happens." In meetings, Leebens said, Comer has "challenged me to stop doing the cognitive work for kids: 'Let them do it themselves. They can do it; they can do it.'" For Comer, she added, it's about "life lessons and also high expectations for kids in letting them see what they can do before the adult decides what they can do." With all the messages out there telling Baychester students what they can't do, Comer will not give up on them, and she won't let them give up on themselves. "These are my kids," she said. "This is my community."

**STRUGGLE**

On Wednesday, May 25, over at East Side Community High School, Soni Midha takes her 10th-grade geometry class out for a lesson on the streets of Manhattan — to measure the height of buildings around East 12th Street and First Avenue. The students face plenty of obstacles: piles of garbage, dog runners, cyclists, construction, a heat wave, taxis and a catcalling gawker who earns a terse reprimand from the object of his attention. "Why you lookin' at me?" says Nasifa, 17. "I'm a minor!" Back in the classroom, the obstacles are more philosophical — thinking, figuring, calculating and coping with frustration — as the students tackle what is known at East Side as a "struggle problem." Actual struggle — the experience of grappling with a problem — is a quintessential part of the learning process at this high school, where there's a poster in every classroom citing the social reformer and abolitionist Frederick Douglass: "If there is no struggle, there is no progress."

First, students face the challenge of contemplating the data they'd gathered. During their field work they had each taken on a role of observer or walker or recorder. The observer stood at point A, across the street from their chosen building (popular choices included a pizza shop and a macaroni-and-cheese restaurant). Using two iPhone apps, they measured the angle of elevation from point A to the top of the building and the distance the walker traveled from point A to point B, at the base of the building. These two measurements gave them crucial pieces of information about a right triangle, and from there — using what they'd learned so far in class about trigonometry — they are now charged with the task of calculating their building's height. But first there are ponderous stares, frowns, diagrams drawn and redrawn amid plumes of eraser dust, and a collective buzz of puzzlement:

"I dunno, man. I really don't know."

"Help! Help!"

But they won't get much help from their teacher.

"I'm the teacher who stopped giving them the answer," said the 30-something Midha. "In every unit that we do, I warn them: 'I'm going to give you the tools that you need, but I'm never going to tell you how to do something. You have to figure out how to do it, you have to figure out the answer, and you have to prove to me why you think that answer is what it is.'" She also offers reassurance through an oft-repeated mantra: "The only way that you can fail is if you give up. If you continue to persevere, if you continue to try, if you continue to work through this, you will get this. But if you give up, you will fail."

Midha has always loved math — it came easily. She suffered some doubts about her abilities in 10th grade, thanks to an algebra teacher who did the standard "chalk and talk" at the blackboard. But during freshman year at Wesleyan University, she took calculus with a professor who considered mathematics to be an art. "Everything he said was so profound," she recalled. "I was like, 'Oh, my god. This is the coolest thing ever.'" And that was that. She became a math major — and also a music major; she plays classical guitar.

Midha decided to become a teacher while still in college, after giving lessons in music, math, Spanish and web design at a summer session for middle schoolers. She applied for the fast-track New York City Teaching Fellows program and got her start at a school in Brooklyn straight out of college, earning her master's degree in teaching at the same time. She taught for four years, and then took a two-year detour, leaving the country and working in marketing and public relations at a fashion house in India. When she returned home, she realized she missed the kids. "Then I found East Side, and I was like, 'This is it.' This is a special place."

East Side Community High School opened in 1992, part of the second wave of a movement of small alternative city high schools that dates to the 1970s. It is part of the New York Performance Standards Consortium, a group of 28 schools across the state that oppose one-size-fits-all standardized testing in favor of performance-based assessment. A recent case study on the school, titled "Learning by Heart," describes East Side as a place that succeeds due to its combined priorities of academic rigor and personal relationships with students. Students came to appreciate just how special East Side was in 2012, when a custodian noticed that the school's 90-year-old brick façade was detaching from its steel frame, requiring an emergency evacuation and a five-month relocation to an impersonal school with windowless classrooms that resembled a high-security bunker. At East Side, by contrast, there is a lot of love. "The teachers love our kids, the kids love us," said Midha, who is like another parent for some students. The school serves grades six through 12 and draws a diverse mix of students, most of whom live on the Lower East Side. More than half of the student body is Hispanic and about a quarter is African-

American; about a quarter receives special education. But 100 percent are governed by inquiry as the lever of learning. On day two of the struggle problem, Midha, dressed in slacks and a T-shirt and New Balance runners that allow her to keep in perpetual motion, provides her students with only select pieces of information and instruction. “I’m going to give you one hint for your struggle problem,” she says. “Here is the one hint I’m going to give you: The goal is to find the total height of the building. The full height. The total height.

“Remember: Where was the angle of elevation measured from? The eye. So when you are drawing and calculating, remember that. Your job is to calculate the total height of the building. … Remember: There is a reason we measured the eye height. There is a reason we measured the eye height.” Repetition, and more repetition, is key for penetrating the adolescent brain.

Midha also provides a bonus hint of sorts, pointing out to her students that they measured the eye height in inches and the building distance in miles, and that the worksheet asks for the height of the building in feet. With that, she leaves her students to their own devices —“Good luck!” She circles the room, surveying the progress, asking simply: “Does it make any sense? … Why doesn’t it make any sense?” Despite her hints, the relevance of the eye height is proving elusive, and the inch-feet-miles conversions are confusing. She reiterates her tips one-on-one with the groups, and then lets them loose again, declaring: “I’m going to walk away now … ”

“Nooo, come back!” Fabian pleads, flipping his pencil in frustration and dinging himself in the eye. Midha and her fellow East Side math teachers recently read 5 Practices for Orchestrating Productive Mathematics Discussions, by Margaret Schwan Smith and Mary Kay Stein. They dissected and discussed it chapter by chapter at their Friday meetings. “It’s about the idea of increasing rigor, increasing the ratio, and the conversations that you have with kids,” Midha said. The “ratio” refers to the amount of discovery and learning the students do on their own versus the amount of explicit play-by-play instruction they receive from the teacher. “Basically, it’s the thinking ratio,” Midha said. “The kids need to be doing the thinking, not the teacher.” Inspiring kids to think, battling their inclination toward intellectual inertia, requires finely tuned orchestration. The book’s five practices consist of anticipating how students will try to solve problems, monitoring their work as they struggle and progress, selecting various students’ approaches to share with the class, sequencing the shared ideas in a logical way, and connecting it all to the overall goals of the curriculum. As Midha did the rounds from one group to the next, these factors were clearly in play — she gently and deliberately coaxed along the conversations, nudging the kids toward a breakthrough, where it all, finally, made sense. "It is pretty powerful when they do have that aha moment," she said. "It's kind of like, not a weight off of my shoulders, but a weight off of my shoulders in my head," said Savannah, 16, who used to hate math. "Suddenly it's like you took a medication or something, you relax and the struggle's gone and you realize the truth — you realize the truth behind the struggle."

**FAIL**

On Friday, May 27, in an affluent suburb west of Boston, Aaron Mathieu introduces a lab experiment to his advanced placement biology students at Acton-Boxborough Regional High School. Mathieu, 42, has a boyish appearance and a voice that sounds alternately serious and laid back. His students scatter into groups, chatting boisterously. Mathieu reins them in with a reminder to prep their test tubes. Then he relaxes, calling the students cherubs, an affectionate term he picked up from his high school physics teacher. (He likes it because, unlike "guys," it "offends everyone equally," he said.) Later that day, in another class, he recollects puns about a recent career field trip to learn what eye doctors do ("the visit was very eye-opening"). His students poke fun at their teacher, calling him a nerd. Six years ago, Mathieu decided to try a risky project in his honors biology class. The students would collect bugs from the school's grounds, grind them up and extract DNA. Then they would try to isolate DNA from a specific type of bacteria living inside the insects' reproductive tracts.

The experiment was complex, and Mathieu and two fellow teachers had spent a couple of years mulling it over and trying to decide whether to attempt it. They were drawn to the project because it combined molecular biology concepts and techniques with the real practice of science. If the experiment was successful, the students had the potential to make novel discoveries — to identify new species carrying that particular microbe, known as Wolbachia pipientis, and to uncover new strains of the bacteria. But the project could turn out to be a spectacular failure. "We were worried about how we would feel as teachers and how the students would feel if they spent five days doing all these novel experimental steps" — extracting DNA, copying sequences, separating them and visualizing the data — only to look down and see nothing, Mathieu said. Most of the existing lab projects in the biology curriculum were designed like a recipe in a beginner's cookbook — with predictable results that almost always came out as planned. But Mathieu wanted to expose his students to the true nature of science — its sense of exploration, the highs of discovery and the challenges of failure. To do that, he knew that he had to remove the safety net. "In order to innovate, we have to take risks and put kids into situations where they take risks," he said. Spending a week on a lab that doesn't work risks squandering limited time and other resources and discouraging the students. "We realized that everyone, teachers and students alike, would learn a lot by attempting the project, even if we did not successfully generate any data," Mathieu said. "To me, the only waste of time is if the students didn't learn from the experience."

The first attempt at the Wolbachia lab ended just as Mathieu and his colleagues had feared — after a week of pipetting, centrifuging and careful note taking, all but one group of students had a blank gel. The students were distraught, focusing only on their missteps and the lack of a clear answer when the project was complete. Mathieu, however, used that response to shape his teaching philosophy. "I took that as a sign they are not learning enough about the process of science," he said. "It meant we needed to embed the process of science throughout the curriculum." Mathieu spent time dissecting the lab with the students, trying to figure out where they had gone wrong. He realized that the students lacked a deep understanding of experimental controls, which help scientists isolate the variable responsible for the outcome. In this experiment, the control was some premade DNA from molecular biology kits. The students amplified DNA both from the insects and from the kit. It turned out that the amplification process failed for both the insect and the control DNA, suggesting that that was the source of the problem. Mathieu and his students improved their process, which now works better, but still not perfectly. "One class this year had amazing data and one class had almost nothing," Mathieu said.

Now, six years later, the process of science has become an essential part of Mathieu's teaching. Several classes of students have performed the insect lab with successful results. But perhaps more importantly, they are better able to analyze the outcome if it goes wrong. Mathieu and his students discuss the importance of controls and other aspects of experimental design throughout the year, and the students now design their own experiments. They have tested whether mice prefer peanut butter or Nutella. (The mice are ambivalent toward Nutella.) They've burned their lawns to explore whether grasslands grow better after fire. (With parental supervision, of course.) They've analyzed how plants respond to aluminum, nickel and lead. "Students need to ask questions, to make choices," Mathieu said. "They need to have some degree of choice and control if they are actually doing science." "Aaron's goal is for his students to do real science in the classroom, not conducting simulations or doing labs that have known answers," said Brian Dempsey, a colleague at Acton-Boxborough who administers the National Association of Biology Teachers' Outstanding Biology Teacher Award in Massachusetts, which Mathieu won last year.

Mathieu, a 20-year teaching veteran, experienced an epiphany after getting his national board certification 10 years ago. As he reflected on his first decade of teaching, he realized he spent a lot of time on the technique of teaching, such as figuring out how to present material. “I didn’t really think of myself as a biology teacher but more as a teacher,” he said. “But I started to wonder how much science was I teaching. Was I presenting the process of science and the nature of science, or was I presenting the history of science? Was I reinforcing the idea that science is a bunch of facts in a book?” Soon after, Mathieu, Dempsey and another teacher began brainstorming how to bring more of the experience of science into their classrooms, a process that culminated in the insect lab. An essential ingredient in teaching the process of science, particularly for freshmen, Mathieu said, is helping students learn how to handle setbacks. He recalls how one honors student would cringe at her biology grades. “That’s a hard emotion to see,” he said. “Not everyone is in a social and emotional place to struggle and learn to deal with the setbacks.” To work past the cringing, he cultivates relationships with the students. As a class, they discuss past challenges and defeats, and what it means to struggle on a test or in a lab. He reaches out to students in different ways, talking with them after class or engaging in discussions via email. He might note that a particular student is struggling with a specific concept and ask if the student wants to sit down and talk about it. He also engages with students on topics other than science. “Whenever possible, I try to have informal face-to-face conversations with students,” he said. “If a group has finished early, maybe they start talking about a game or some other event — I’ll get involved in that conversation.” As a result, the students have learned to deal with an experiment that flops, and to understand that in science, failure is far from a dead end — it’s a result in itself. “At the end of two weeks, we might look at a gel and see nothing, and that’s ok, because that’s what happens in science,” Mathieu said. Instead of thinking that the experiment was a waste of time, they’ll try to figure out what went wrong. Which part of the experiment failed? How can they improve it next time? Some students are so driven to figure out what happened that they come back after class to redo the experiment.

**ENGAGE**

Earlier that same Friday, two men are shot in a car just steps from Baychester Middle School. Both are taken to nearby Jacobi Medical Center, where one dies. A crime scene unit seals off Baychester Avenue.

The school day begins as usual. After lunch, students from the “UC San Diego” homeroom arrive in Comer’s classroom for science. “Good afternoon, San Diego,” she says, beaming. “Good afternoon, Miss Comer!”

"We're going to be continuing with our toy car labs," Comer announces. A highlight of her simple-machines unit, the lab involves building a ramp and testing how fast a toy car rolls down when the ramp is covered with different materials. "What's the concept that we're studying with the toy car lab?" Mylani raises her hand. "Friction." "What is friction?" Comer asks. A few students offer partial answers. "We said it was a force, we said it has to do with surfaces, it has to do with slowing things down. Who can put it all together into one neat package?" After another try, she calls on Cameron, a soft-spoken boy who didn't get along with her at first but is now one of her top students. "It's a force between two surfaces that makes moving an object easy or difficult," Cameron says.

Soon students are buzzing in groups, defining roles and deciding which coverings to put on their ramps. As Comer monitors their progress, she probes individual students to gauge understanding. "Why is the speed of the car the dependent variable?" Two of Cameron's teammates correctly explain that it depends on the covering on the ramp. Then: "What's the independent variable?" "The covering on the ramp," Sincere answers. He and another boy sport Baychester blue headbands with orange letters that spell TRAIN. "What is the control in your experiment?" Comer asks. This stumps the group. "Well, what is a control?" she prods. Blank stares. She decides to review these concepts with the entire class. When she's satisfied that everyone groks the basics, off the kids go to gather their materials and build their ramps. The classroom becomes a construction zone. Shawn Mangar, the principal, called Comer's class the loudest at the school, but loud for the right reasons: Students are thinking and learning in "controlled intellectual chaos." And it works: "In the beginning of the year I wasn't really interested in science because at my old school we didn't do a lot of science," Shomari said after class. But now, she said, "what I like about science is that you can experiment with different things and you can challenge other people's opinions."Likewise, Cameron said that at his old school, "we just read textbooks and stuff." He loves the hands-on projects and the fact that Comer goes "deeper into things." Last winter, when there was ice on the ground, he thought about friction and where to place his feet to avoid slipping and falling. "I like the way that she teaches," he said. "She never rushes. We just take our time." The school's founders never planned for science to be a focal point at Baychester. "We never expected it to take off the way it did," Mangar said, crediting Comer. "You can see a student struggling in two or three classes and all of a sudden they're a rock star in science class."

**MODEL**

"Real quick, everybody just come up to the table real quick," Michael Zitolo instructs his Physics 1 class on Thursday, May 12, at School of the Future, a public middle and high school that rises 11 stories above the base of midtown Manhattan. "Can I have you come around this way? Danny, you're going to want to come a bit closer. I showered; I don't smell too much." The students gather around their teacher. Bald and bearded and, as always, wearing a science-themed tie, Zitolo sends two windup toys, a car and a duck, whirring across the tabletop. "When you wind up one of these windup toys, does anybody know what's on the inside of these things?" he asks. "A spring!" "It could either be a spring, or some sort of elastic rubber band material," Zitolo says, explaining that either of these can store potential energy that gets unleashed as kinetic energy when the duck walks. It is the first day of a monthlong unit on energy that Zitolo has carefully curated. The students mull over demonstrations, thought experiments and video clips to familiarize themselves with the way energy transforms from one type to another, and then they practice graphing those changes in a series of bar charts.

"Quick disclaimer — do engineers actually use these bar charts in their analyses? No," Zitolo says. "They do this in their head, because they have a deep understanding of how energy transformations occur. We're doing these on paper for now until we get comfortable doing these things in our head. And then these are actually going to be our launching point to create our mathematical models." This evening, the students will write a one-page "mastery reflection" on using bar charts to model energy transformation. And through further experimentation in the weeks that follow, they will develop mathematical abstractions or "models" that describe energy's behavior, essentially deriving for themselves the equations that most physics students memorize from textbooks. Called "modeling instruction," it's a pedagogical approach that is surging in popularity among physics teachers. Modeling instruction won the 2014 Excellence in Physics Education Award from the American Physical Society and has been shown to yield higher scores than traditional courses on the force concept inventory, a test that gauges students' conceptual understanding.

But Zitolo did not always teach this way. When he first entered the profession — and his seventh-floor classroom at School of the Future — almost 10 years ago, he felt as though he was drowning in a sea of concepts. He was somehow supposed to instill a thorough knowledge of forces, kinematics, energy, electricity, magnetism, waves, modern physics and more in students whose prior notion of physics consisted of the word "gravity." He couldn't keep up. And the students who passed through his class rarely went on to study science or engineering in college. Meticulous about everything from beard trimming to his annual go-for-broke Halloween costumes (which earn him schoolwide respect), Zitolo was obsessed with self-improvement. "I was of this mind that there is a perfect way to teach physics, and I just have to figure out what that perfect way is," he said. "I was very hard on myself my first couple of years. I literally, one year to the next, could not look back to what I did in previous years, I thought it was so horrible."

The biggest breakthrough came the summer before Zitolo's fifth year of teaching, when he attended a three-week workshop on modeling instruction. Mark Schober, a physics teacher and former president of the American Modeling Teachers Association, called modeling "a grassroots movement" that grew in the 1980s largely out of the classroom practices of an Arizona physics teacher named Malcolm Wells. The movement has expanded to 78 workshops this past summer; as of 2015, more than 10 percent of the nation's physics teachers had attended one. In modeling courses, instead of first teaching physics concepts in the abstract and then connecting them to the real world through labs, teachers have students experiment with model systems — a windup toy, for instance, or a cart held by a pulley at the top of a ramp — and guide them as they develop mathematical models of the systems, which they can then apply to other problems and settings. Modeling instruction is "a lot of Jedi mind tricks," Schober said. "How do we shape students' thinking without them knowing we are? We want them to feel the idea is really theirs — they came up with it."

Modeling is not a one-size-fits-all teaching method, but is rather tailored by teachers to suit their individual styles and skills. Zitolo, who has an engineering bent, casts his modeling unit on energy as a project to design a roller coaster. In class on May 12, he asks students to imagine dropping a ball from the top of the school building. When the ball hits the ground, he explains, the friction converts some of the ball's kinetic energy into thermal energy — a form they were supposed to have read about the night before. "Why does this matter?" Zitolo says. "Roller coasters. Even though the tracks are designed to be super smooth, and even though they are supposed to be streamlined to reduce drag, there is going to be drag; there is going to be friction. You guys are going to have to account for that when you design your roller coasters."

Like East Side Community High School, School of the Future has opted out of the statewide Regents examinations, and this has facilitated Zitolo's switch to modeling. Student-run experiments and data analyses take longer than lecturing, and so modeling courses typically cover less ground than a traditional physics curriculum. But Zitolo has found that, compared to skimming a sea of concepts, deeper dives instill a deeper appreciation for physics — even in students who are destined for other vocations. “I’m going for public communications, not anything to do with physics,” said Nikki, who graduated in June and now attends Syracuse University. “But being in Z’s class — it really has opened my mind to, like, wow, this is cool, I get to build things, I get to see how things affect one another.” Zitolo, now 32, made up his mind to become a physics teacher as a senior at New York University, even though his family, friends and mentors encouraged him to “do something real” with his physics degree first. Teaching “gives me the ability to be creative,” he said. He gets to share his passion for physics with students “and hopefully inspire that same passion in them.”

**TRAIN**

A week into his May unit on roller coasters, Zitolo and about a dozen other science teachers meet at a building on 21st and Broadway for pizza and an evening course led by Channa Comer. Comer and Zitolo have been friends for years, having participated in many of the same professional development (or “PD”) activities. After chatting with him and other participants about the rapid approach of summer, Comer launches into the benefits of using primary sources such as maps, original documents and diagrams in the science classroom to help engage students. During the course, which is sponsored by Math for America, a nonprofit organization that aims to improve public math and science education by providing a comprehensive support system for teachers, the cohort brainstorms ways of integrating primary sources into their curricula. “Sometimes when I start a unit, I have them do research on, like, the physics of roller coasters,” Zitolo says to his tablemate, Bianca. “But maybe I could also kick them off with, like, a little bit of the history of roller coasters that I could provide, to see how they’ve evolved over time.” He begins to search the Library of Congress website. When Comer decides to do something, she’s not one to just dip a toe. Years ago, at a bodybuilding show, she looked at the woman who won and thought, “I could do that.” So she did, training two to three hours a day, radically altering her diet, taking supplements like medium-chain triglycerides (to burn fat) and zinc (to increase blood flow and vascularity), tanning and practicing poses. “It’s a crazy lifestyle,” she said. “It costs so much and you can’t walk past a store without checking your muscles.”

She quit bodybuilding after four years out of concern for her metabolism, pocketbook and humility. Now she’s into yoga and belly dancing, both of which she’s certified to teach. When she became a science teacher nine years ago, she threw herself into the work just as she does with everything else. She trained hard over weekends and summers, partly for the extra income — some fellowships offer generous stipends — but also to "build my own content knowledge, because I came into this with a scattering of science in different areas," she said. "She's done more PD than any other teacher I know and is constantly integrating what she learns into her curriculum," Zitolo said in an email. Among her teacher friends, Comer said, "I'm known as a PD junkie." During her first year as a teacher, she wanted to observe more accomplished teachers, but she and the other two science teachers at Urban Assembly Academy were all relatively inexperienced. So she convinced her principal to let her spend one day a month observing teachers at other schools. One month, she visited New Design High School on the Lower East Side to observe David Rothauser, a teacher known for giving students ambitious design challenges. "That's when I started doing engineering design challenges and using 'design thinking,'" she said. Design thinking involves figuring out "all the different ways we could solve a problem." Many of her former high school students who didn't go to college now work for the parks department, in restaurants or in retail. Without marketable skills like design thinking, she said, "those are the only things that are available to them. I think the whole system needs to be changed and the focus needs to be on thinking and not so much on facts."

Rothauser said he was immediately impressed with Comer's ability "to improvise within the system," adding that "it felt wonderful to be discovered by her in that way." Comer went on to become a master fellow in the Sci-Ed Innovators program he was helping to run, and later joined the leadership team.
Over the next several summers, Comer participated in teacher research programs in neuroscience, nanotechnology and robotics, took workshops in molecular biology at Cornell University, and participated in sea scallop surveys with the National Oceanic and Atmospheric Administration. Comer and Zitolo became fast friends during the Summer Research Program at Columbia, which she considers one of the best PD opportunities because it runs for two consecutive summers in the same laboratory, offers a generous stipend, involves collaboration with experts, and focuses on both research and pedagogy. The two have also participated together in the Smarter program at New York University's Polytechnic School of Engineering, and they were Sci-Ed fellows the same year. All three of these extended programs provide training that goes well beyond what's offered in the one-off workshops that many teachers attend. They also include "a mechanism for follow-up to assess implementation and effectiveness of the PD," Comer said. "In my experience, the programs that I have participated in that fit these criteria have had the greatest impact on my teaching practice." However, a paradigm shift in professional development will not come easily. "Teachers have been conditioned to expect PD where they

walk away with something that they can use in their classroom immediately, rather than working through a process that may take some time to develop and yield results." In Acton, Massachusetts, Aaron Mathieu networks with scientists and other teachers, figuring out how to improve experiments, convincing researchers to donate agar plates or other materials for new projects, and arranging lab visits for students. Everyone Mathieu meets is fair game. He has recruited biologists he met at his sons' elementary school picnics and soccer games to host career shadowing visits.

Mathieu works with Natalie Kuldell, an instructor at the Massachusetts Institute of Technology who runs the BioBuilder Educational Foundation, a nonprofit organization that teaches synthetic biology and runs summer workshops to train teachers in bioengineering. He's also been in touch with Seth Bordenstein, an evolutionary biologist at Vanderbilt University who helped develop the insect DNA lab that Mathieu implemented five years ago.

Soni Midha's approach to professional development is immersive, in part out of necessity. She teaches four classes and meets with a math coach and her fellow math teachers. "We geek out," Midha said. They talk lesson plans and curriculum goals, and they often begin a meeting by doing a math problem themselves. Broadly speaking, their goal is to reflect upon teaching and to improve. With that in mind, Midha and her colleagues read the book A Mathematician's Lament, a landmark critique of the nightmarish state of mathematics education by Paul Lockhart, a math teacher at Saint Ann's School in Brooklyn. Lockhart chronicles the standard rote approach, in which students are told, "'The area of a triangle is equal to one-half its base times its height.' Students are asked to memorize this formula and then 'apply' it over and over in the 'exercises.' Gone is the thrill, the joy, even the pain and frustration of the creative act." Lockhart argues that mathematics should be taught as "an art for art's sake": Mathematics is the purest of arts, as well as the most misunderstood. … If there is anything like a unifying aesthetic principle in mathematics, it is this: simple is beautiful. Mathematicians enjoy thinking about the simplest possible things, and the simplest possible things are imaginary.

… That's what math is — wondering, playing, amusing yourself with your imagination. …

… People enjoy fantasy, and that is just what mathematics can provide — a relief from daily life, an anodyne to the practical workaday world.

For Midha, the daily regime has her watching the clock, timing lessons down to the second. She arrives at school as early as 7:30 a.m. The final bell rings at 3:30 p.m. She has a 50-minute lunch period, which she often spends meeting with students or keeping up with work. She tries not to take her grading home, but she often does. Sometimes she gives over her spare time to professional development. A few years ago she took a Math for America workshop led by the Stony Brook mathematical artist and educator George Hart. He entranced a classroom of teachers with what he calls a sculptural "barn raising" — the collaborative construction of a giant starlike polyhedral sculpture suspended from the ceiling. The sculpture consisted of 60 identical interlocking cardboard pieces, which formed the 20 faces of a regular icosahedron, with fivefold, threefold and twofold axes of symmetry. "That just kind of blew my mind," Midha said. Last fall she took a three-part workshop with Hart and then jumped at the chance to have him visit East Side Community High School, where he gave two workshops for students featuring colorful constructions of a "paper triangle ball" and a "paper square ball." Both were exercises in pattern recognition and visualization, with logical constraints. But the takeaway, Midha said, was, simple: "Math is fun — it can be beautiful; it can be art."

Working with teachers like Midha, who are rigorously curious and creative, is a joy, Hart said. "There is a wide range of teacher abilities," he said. "Lower grades often have teachers who are afraid of math, and they pass that on to their students." Midha, he recalled, was clearly one of those teachers who love being challenged to think in new ways. "And because she enjoys that experience," he said, "I'm quite certain that she's going to pass that on to her students."

The Sci-Ed Innovators program that Comer and Zitolo both attended initiated the second major curricular shift of Zitolo's career. It was his seventh year in the classroom, and although his switch to modeling instruction was starting to pay dividends, he was still striving for better ways to engage his students. As he developed his curriculum during evening Sci-Ed meetings, he started teaching his Physics 2 class the basics of computer programming, a skill he himself had picked up in college. A few of his best students agreed to showcase their final projects — electronic devices they built and programmed — at Sci-Ed's 2014 science fair. One of the students, Hannah Parker, designed a health monitor; another built a theremin. On the morning of the fair, Zitolo got up early and baked cookies to calm his and his students' nerves, worrying that their gadgets might seem trivial or out of place. But as soon as the fair started, their table was swarmed.

Zitolo has since added even more electrical engineering and computer science to Physics 2. This past spring, students built complex devices like motion detectors and musical keyboards. "We're coding, like hackers! It's insane," said Nikki, who built a fan that turns on in high humidity. Each year, several students in the class participate in a citywide program called ACE

(Architecture, Construction, Engineering), and many have earned engineering scholarships. Parker, now a math major at the University of Rochester, plans to become a high school teacher. “I want to be Mr. Z,” she said. Zitolo is now in his 10th year of teaching. Perfection has turned out to be an unreachable goal, of course, rather like the finish line in Zeno’s paradox. But through a series of major and incremental refinements to his pedagogy, he is now a model physics teacher.

**ACHIEVE**

On Wednesday, June 22, as the school year winds down to its chaotic end, Soni Midha barely has time to think straight. She’s been preparing for her day of “roundtables,” a key component of East Side’s performance-based assessment structure (the school does not participate in the standardized statewide Regents’ examinations, though students do take finals). Each student presents on one of the main subjects they tackled over the year, such as a struggle problem. The students then answer questions from an audience of two peers and a judge, who bestows not grades but a designation of novice, apprentice, practitioner or expert. With eight sessions scheduled over the course of the day, the hallway outside the roundtable room is a constant catwalk of congratulatory razzing.

“How’d you do? Did you fail?”

“No, I got expert!”

“Oh, so you failed.”

Inside, it’s serious business for the presenters, who deploy overhead projectors, cue cards and a personal cover letter, addressed, “Dear Evaluator.” “Welcome to 2016 geometry roundtables,” begins Reon, who notes that he’s into fashion and styling. Wearing a tie-dyed T-shirt with a collage of nuns, skeletons, centipedes, candles, President Obama and equilateral triangles, he presents his building-height struggle problem and his trigonometry work. “I remember the day Soni introduced the topic to us and I said, ‘Trigo what?’” But, as he continues in his letter, “my favorite topic of this semester turns out to be trigonometry, shockingly.”

Janet, in her letter, confesses, “Math and I haven’t always been on good terms. In middle school I used to despise math, I would get so annoyed and frustrated.” But she aces the roundtable, receiving a hug and high-five from Midha and the designation of a grade-10 geometry expert. “Even though I hate something, I’m still going to try,” she says. In a sense, math is a metaphor for life. And the ability to solve problems and think independently is ultimately the lesson that Midha hopes to impart. “You struggle in math. You struggle in life,” said Midha, who by way of example often tells her students about her struggles with classical guitar. "It takes me forever sometimes to get through a piece. Because it's so hard, and it sucks, and I don't want to do it. But I keep going because I know I want a successful outcome, I know I want something really great at the end." The same applies to Midha's goals as a teacher, a job she anticipates doing forever (this year she's teaching calculus for the first time). "I'm not saying there aren't days when I'm, like, 'Uhhhh, I don't want to do this.' There are always days where we all kind of just need to take a break. But I'm an educator for life. No admin dreams here. Teacher for life, that's the goal."

**THANK**

On July 28, exactly a month into summer break, Channa Comer is in her Bronx apartment, hemmed in by plants, keepsakes from overseas research trips, a rack of immaculate vintage clothing she plans to sell online, and her two timid cats, Lucy Luu and Teena Turner. She's sorting through boxes of quirky drawings and letters from some of the estimated 1,000 kids she's taught over the past nine years. She has moving companies to interview and boxes to pack.
Comer waited until the last week of school to break the news to her students, not wanting it to be a distraction. She was leaving Baychester Middle School. She was done teaching. "I love these kids. I love them," she said. "But the system, I think, is extremely flawed, and I just need a break." In late August, she began her move to Maryland, where she could commute to the Department of Energy's Office of Science in Washington, D.C. Months earlier, she had been accepted into the Albert Einstein Distinguished Educator fellowship program, where she hopes to gain a broader perspective on national educational policy.

Why do master math and science teachers, who are passionate about their content area and about developing their craft, who are creative, smart and engaging, and who adore their students — why do they quit teaching? Some have given all they can; they're burned out from thinking and worrying about their students seven days a week, and from battling with school officials over resources, scheduling, a shortage of support, and an abundance of rigidity. Often these talented, driven individuals are lured away by career options that offer greater professional stature and higher pay. And some are just so naturally adventurous that they were always bound to move on. For Comer, it was all of the above. "I'm really proud of the body of work that I've built as a teacher," she said. "I don't know how it will be to be in an office all day instead of in the classroom dealing with students and meltdowns and singing and dancing." But there are some things about teaching she will not miss: "There needs to be much more flexibility, much more autonomy given to teachers to be able to create and teach to their passion so that they can engage students more deeply."

By all accounts, including Comer's, she was given extraordinary freedom and flexibility by her principal and school. "Channa's earned the ability to do things her way," said Principal Mangar. "Anytime she's asked for something, or asked, 'Can I try something?' she's outperformed expectations. I see myself as an offensive lineman — clear the way for her to be able to do good work." Still, she got dinged (by administrators other than Mangar) for transgressions like failing to write a learning objective on the board before every class. Comer says she did not have time for that after class periods were shortened from almost an hour to 45 minutes. And besides, her projects and learning objectives, which students recorded in their notebooks, took days or weeks to complete. "It's an incredible loss for her students and her school because through all her experiences and bringing them back to the classroom, whatever teacher comes next can't bring what she brings," said Michael Zitolo, who admits that the Einstein fellowship is a logical next step for his friend. He hopes her voice will be powerful at the national level, that she can push for fewer discrete standards and more "big-picture ones" like the Next Generation Science Standards. "You can't replace someone's passion," Mangar agreed. For his part, he hopes Comer will return after her 11-month fellowship ends. "I have a calendar reminder for when to contact her," he said. "She's always welcome. This will always be home."

Even in the chaos of relocating across state lines and dealing with broken elevators, gridlock, a thunderstorm, moving company miscalculations, and other delays, Comer found time to pen a lengthy email criticizing the way science is currently taught: "I think we are approaching it wrong. I don't think science at the lower levels should be separated into discrete subjects, but rather integrated and taught in the context of real life." She said she would be happy to discuss these ideas further, and that she'd be back in New York until August 24, after which she'd be in Maryland "for good."

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