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Prepare Your Mind for Creativity

An asset in most cases, extensive experience can trip up the adoption of new technology—when fresh thinking is needed above all else. But methods exist to recognize impediments to creativity and to sharpen rusty creative skills.

The adoption of new technology often disrupts an organization—the business environment changes, rules change, and the tried-and-true methods of conducting business lose effectiveness. A creative approach is needed to best match technology solutions to business problems in such situations. If they are to prosper, organizations must identify and nurture creative employees, who for their part must maximize their creative potential to remain employable. But how? For one, individuals and organizations alike can benefit from increased awareness of the key behaviors known to enhance creativity, as well as those that impede it.

Creativity is rather difficult to define but easy to recognize. Cognitive psychologists who study creativity call a product or service "creative" if it is at least novel and useful. The usefulness criterion need not exclude works of art or entertaining productions, and the novelty criterion can be satisfied at either a personal or societal level. If a student produces a bubble-sort program without previous exposure to the bubble-sort algorithm, the program is a creative work for that student. Such personal novelty is far more commonplace than societal novelty, which occurs when something never before experienced is produced. The first bubble-sort program, the first network, and the first computer virus are examples of societal novelty. When measures of novelty and usefulness are combined, mundane and exceptional creativity become endpoints of a continuum used to rank creative productions, as illustrated in Figure 1.

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Figure 1. Creativity scale with examples.

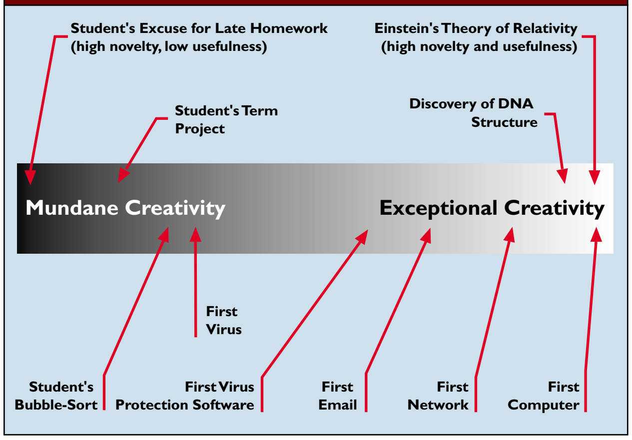
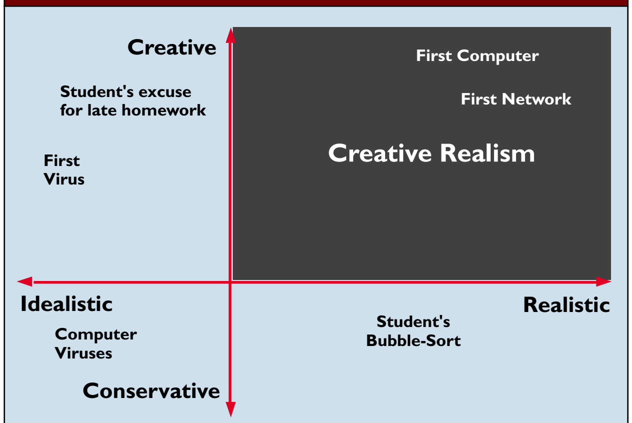


Figure 2. Alternative creativity scale wiith example.



Adapted from [4], page 306.

By nature, humans are creative and some believe it is this trait that distinguishes humans from other animals [12]. All humans don't appear to be equally creative or have equal creative potential, however. Efforts to predict creative potential include measures of personality type, general intelligence, and performance on creativity tests that correlate puzzle-solving ability to general creativity. Each of these methods has some statistical validity, but the more commonly used indicators tend to be more direct: actual creative output and mastery of the discipline.

Measuring creativity by creative output relies on the assumption that those with higher creative potential have higher creative output. This measure, which has been used to validate less direct assessments of creativity, like intelligence, personality type, and problem solving ability, has commonsense appeal, but it also has two major drawbacks. First, assessments of creativity are extremely subjective, situational, and sometimes, wrongheaded. Einstein's special theory of relativity was largely ignored by Poincare, Mach, Plank and Lorentz—among the most revered scientists of that time [4]. *The Rite of Spring*, one of Stravinsky's most famous works, originally met with hostility [4]. Friends and critics alike reacted adversely to Picasso's *Les demoiselles d'Avignon*, a work now believed critical to the rise of cubism [4]. Failures to recognize creative potential are not unique to the creative arts. AT&T declined to take over the operation of the ARPAnet in the early 1970s because it was incompatible with existing telephone networks [8]. In the early 1980s, both Prime Computer and Digital Equipment turned down the opportunity to be involved in what became Sun Microsystems [8].

Measuring creativity solely by output also lacks dimensionality. A useful alternative to the one-dimensional creativity scale in Figure 1 is Finke's two-dimensional creativity scale [3] (see Figure 2), which contains four categories of creative output: creative and conservative idealism, and creative and conservative realism.

Creative idealism describes novel products of limited usefulness, while conservative idealism describes products low in both usefulness and novelty. Conservative realism describes products that, while not highly original, are useful, and creative realism denotes useful novelty. While this approach does not make judgments of novelty and usefulness any easier, it eliminates the need to combine measurements into a single composite score.

Mastery of the discipline, the second method for assessing creative potential, relies on the observation that creativity tends to be domain-specific—that is, most highly creative people are creative only within a single discipline [4, 7]. The usefulness of mastery as a measure of creative potential lies in its availability. No tests of creativity, intelligence, or personality need be administered; an examination of work history and demonstrated knowledge of the field will suffice. When taken together, actual creative output and mastery of the discipline are the most direct and accessible indicators of creative potential.

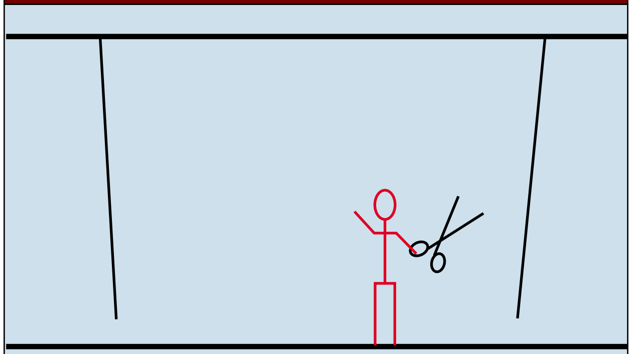
Fostering Creativity

Having identified creative individuals, organizations need to protect and nurture their talents, enabling them to perform up to their potential. Numerous self-help guides on the market teach creativity-enhancing techniques for individuals and groups. One of the best for IS professionals is Couger's *Creativity & Innovation in Information Systems Organizations* [1]. Couger gives the same advice for nurturing creativity that the works of Tom Peters and others have made almost cliche:

- Because not all creative efforts will be fruitful, organizations must be willing to take risks and tolerate failure.

- Managers should shield employees from any external forces, particularly those within the organization, that tend to discourage creativity.
- Managers should reduce workload pressure, especially unrealistic deadlines and excessive productivity expectations.
- Managers should be supportive and encouraging of creative endeavors.
- Employees should have freedom to pursue ideas and to decide how to do their jobs.
- Employees need challenging work, along with awareness that what they do is important.
- Sufficient resources must be available for employees to accomplish their tasks.

Figure 3. Two-string problem.



The subject must tie the free ends of the strings together.

Unfortunately, implementing these suggestions is not enough to ensure the fostering of employee creativity. Other impediments to creativity exist that self-help books tend to overlook. One is the effect of prior knowledge on creative efforts. Cognitive psychologists use two terms to describe this effect: fixation and structured imagination. Fixation—sometimes referred to as "mental rut" [9]—is an inability to switch from an inappropriate solution approach to a more productive one, while "structured imagination" refers to the common tendency not to deviate from what is already known during creative efforts.

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A classic example of fixation occurs with Luchins' water-jar problems [2]. Here, subjects are told they have an infinite supply of water in one reservoir, several different size containers for transporting water, and a second empty reservoir into which a precise amount of water is to be transferred. Several problems are presented that can be solved using the same algorithm. A final problem is presented that cannot be solved using this algorithm—but can be solved using an easier method. Subjects take substantially longer to solve the final problem than the previous ones.

Subjects working on the water-jar problems tend to mechanize one solution method. This kind of mechanization has also been observed in an introductory programming course when teaching for-loops. When given a series of examples in which the for-loop is summing elements in a table, and the addition statement is then replaced with a move statement, virtually the entire class will give the same incorrect response. Students will continue to sum the elements from the table, even though the critical line of code does not contain any arithmetic operators. Merely stating that the response is incorrect and circling the offending line of code generally produces a collective "ah ha" from the class. Students know the difference between addition and assignment, but the mental set induced by previous problems prevents them from retrieving the appropriate solution method from memory.

Fixation may also result from functional fixedness, or inability to use familiar objects in an unfamiliar way. A classic example is Maier's two-string problem [2]. Here, a subject is placed in a room where two strings hang from a ceiling. He or she is asked to tie the two strings together without moving the anchor points of the strings or modifying the strings. The strings are sufficiently far apart so it is not possible to grab the end of one string and walk over to the other, as shown in Figure 3. The only other object in the room is a pair of scissors. The challenge is to use the scissors as a pendulum bob rather than to cut the strings. After tying the scissors to the end of one string, the subject can set the pendulum in motion. Then, while holding the end of the other string, the subject can catch the scissors, thus bringing the ends of the two strings together.

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Functional fixedness can also be observed in an introductory programming class, when students are required to produce traditional Input-Process-Output charts. Most students produce these charts using a three-column table, which is perfectly acceptable, but most don't realize the table needs only one row. Students tend to isolate each line of text in the IPO in its own row in the table, making the chart more difficult to change when errors are discovered. While there is nothing in the software to dictate this decision, students are unable to overcome the idea, established in earlier courses, that a table cell contains a single number or line of text. Similarly, when the programming language syntax for creating matrices is introduced, students have difficulty using complex data structures as an element of the matrix. The idea that the function of a cell in a table or an element in a matrix is to hold a single piece of information is difficult to relinquish. This difficulty is symptomatic of functional fixedness.

Fixation in the Late 1980s.

A small third-party administrator of employee benefits produces a large quantity of reports from its nightly batch processing. Some reports must be sorted and printed in two different sequences while others must have an associated summary report.

Rather than constructing a subroutine which could be called upon after each sort, the individual primarily responsible for the original programming of these reports elects to duplicate code within these programs such that most of the programs contain twice the lines of code necessary to accomplish the task. Also, the idea that summary reports could be produced simultaneously with the more lengthy detail reports and simply written to a separate file never occurs to the programmer. In these programs, not only was the program size excessive, processing took twice as long because two passes were made through the input files when one could have done the job.

The large quantity of redundant code makes maintenance a nightmare. The quantity of redundant processing increases until nightly processing can no longer be completed in the available time. C

The classic experiments in structured imagination, another problem of prior knowledge, ask subjects to imagine life on a planet (dis)similar to Earth, and to sketch examples of these life forms [10]. The majority of subjects produce creatures with bilateral symmetry and obvious sensory organs, even when instructed to be as wildly imaginative as possible. The undergraduate psychology students normally subject to these experiments are not the only ones suffering from structured imagination. In design experiments with professional engineers, subjects given product specifications and asked to sketch possible designs tend to include design features they have been exposed to previously, even when those features make the product unusable [6]. Another example of structured imagination is the continued use of two-digit date fields years in information systems long after all reasonable arguments in favor of this practice have been dismissed. In fact, this practice is so ingrained in the culture that some current programming textbooks still use two-digit years in their examples, even when they feature a discussion of the Y2K problem [5].

Overcoming Creative Limitations

When in the midst of grappling with an intractable problem, it can be difficult to distinguish between structured imagination and fixation, but this distinction can help prescribe a cure. Treatments for fixation include procrastination, or a time period where one is not consciously working on the problem, and altered context [9]. When either treatment produces an *insightful* solution to the problem, incubation is said to have occurred. Insight is the "eureka" or "ah ha" phenomenon so often described in studies of creativity.

Structured imagination is not remedied by procrastination or altered context. While those suffering from fixation are usually all too aware they have not solved the problem, individuals experiencing structured imagination remain blissfully ignorant of their failure. Procrastination is effective against fixation because the individual knows how to solve the problem but inappropriate knowledge is blocking retrieval of the needed information. Procrastination alone cannot alleviate structured imagination because the required knowledge is simply not there. Recognizing the problem has not been solved is the first step in overcoming structured imagination. Following recognition, acquiring knowledge of alternative approaches, and increasing the level of abstraction at which the problem is addressed are the best methods for overcoming structured imagination [11].

Pasteur once said, "chance favors the prepared mind." A review of the creativity literature reveals three categories of knowledge essential to prepare the mind for creative endeavors.

- **Knowledge of the domain in which one intends to create**. In order to be creative one must seek out problems and develop solutions. Without knowledge of what is going on in the field, one will be hard-pressed to identify unmet needs. Furthermore, an understanding of what has been tried in the past and why it failed is essential to avoid repeating mistakes.
- **Knowledge of techniques that enhance creativity and factors that inhibit creative efforts.** This knowledge cannot guarantee a solution to every problem, but given a variety of creativity enhancing tools and an understanding of their appropriate application, one need not be a victim of fixation or structured imagination.
- **Knowledge of other domains.** Knowledge of other domains provides the material needed for constructing useful analogies, which several creativity-enhancing techniques incorporate. Also, one domain may have a solution that can be adapted and reused in another.

In addition to knowledge, a distillation of self-help books and studies of creativity suggest four behaviors to help prepare the mind for creativity.

- **Learn something new every day.** The body of knowledge needed for creative endeavors in any field is growing and changing constantly.
- **Seek out constructive criticism.** Structured imagination is insidious because its victims are generally unaware of its effects. When developing products intended to solve business problems, constructive criticism is needed in order to detect ersatz solutions. When the occasional failure occurs, it should be treated as a learning experience.
- **Incubate.** Most people have experienced wrestling unsuccessfully with a problem they know is solvable. Our knowledge of fixation suggest that, under these circumstances, it is often best to walk away from the problem for a while. This period of procrastination need not be idle. The term productive procrastination describes periods when some work is suspended to allow for incubation, while work on other projects continues.
- **Above all else, put knowledge to work.** Many of those regularly engaged in problem-solving activities have intuitive awareness of fixation and structured imagination effects, as well as of the importance of the three types of knowledge and the four behaviors mentioned here. Unfortunately, knowledge alone is not enough. It is necessary to practice the behaviors.

If the programmer from the sidebar "Fixation in the Late 1980s" had sought constructive criticism, he would have received a few relatively simple design suggestions that could make a dramatic difference in the performance of the nightly processing system. Or, if the programmer had made efforts to learn more about software design or to study methods used by others to implement similar systems, he might have discovered the solution himself.

Similarly, if the employees described in the sidebar "Structured Imagination in the Early 1990s" had taken time to incubate, they might have arrived at a better solution to the nightly balancing problem. However, because the transaction-processing system example in the sidebar represented the only project for the individuals involved, the client involved was the largest user of the product, and "idle time" was not acceptable to the management of the firm, an immediate solution was required to allow the group to move on to other issues.

Structured Imagination in the Early 1990s

A small software firm produces, markets, and supports a mainframe-based transaction processing system whose major strength is its nightly balancing of all accounts in the system. The standard procedure requires the system manager to examine each night's reports and verify that various totals balance. This process works well until the product becomes popular with larger clients, and several hours are needed to verify the previous night's processing. Because the system manager has been using a spreadsheet application to assist the balancing process, someone proposes producing an additional report with all the required totals, to make data entry easier.

But the idea of producing reports on paper rather than to a file that could be imported into a spreadsheet application is a clear case of functional fixedness. Additionally, if all totals can be brought into a single program for reporting, why could the program not also verify that the totals balanced?

Conclusion

The self-help industry offers good advice on enhancing creativity, but tends to overlook the detrimental effects of prior knowledge. When the task of implementing new information systems is undertaken by people more familiar with the old ways of doing business, both fixation and structured imagination are predictable consequences and the results of these efforts are likely to be unsatisfactory. This does not mean these experienced individuals are no longer assets to the organization, but simply that these individuals must make the effort to learn about new technology, business practices, and ways of meeting business needs with technology solutions. They must also learn to recognize and take precautions against fixation and structured imagination. Through awareness of impediments to creativity and the use of creativity-enhancing techniques, individuals and organizations can maximize their creative potential and better meet the challenges of a dynamic business environment. **C**

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