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"Software testing is the process of applying metrics to determine product quality.

Software testing is the dynamic execution of software and the comparison of the results of that execution against a set of pre-determined criteria."

 National Institute of Standards and Technology, The Economic Impacts of Inadequate Infrastructure for Software Testing, 2002



Testing: The process of operating a system or component under specified conditions, observing or recording the results, and making an evaluation of some aspect of the system or component.

 IEEE Standard Glossary of Software Engineering Terminology, 1990

"Testing is any activity aimed at evaluating an attribute of a program or system.

Testing is the measurement of software quality."

 Bill Hetzel, The Complete Guide to Software Testing, 1983



"Testing is the act of executing tests. Tests are designed and then executed to demonstrate correspondence between an element and its specification.

There can be no testing without specifications of intentions."

 Boris Beizer, Software System Testing and Quality Assurance, 1984



"We should run test cases not to look for bugs, but to increase our confidence in a program we are quite sure is correct; finding an error should be the exception rather than the rule."

 David Gries, The Science of Programming, 1981



"One usually encounters a definition such as,

'Testing is the process of confirming that a program is correct. It is the demonstration that errors are not present.'

The main trouble with this definition is that it is totally wrong; in fact, it almost defines the antonym of testing."

 Glenford Myers, Software Reliability, 1976



"Testing should strive to be predictable, dull, constrained, rigid, and inhuman."

 Boris Beizer, Software System Testing and Quality Assurance, 1984





"Testing, particularly test case design, is the area of software development that demands the most creativity."

 Glenford Myers, Software Reliability, 1976





"Testing is the process of executing a program with the intent of finding errors. ... This definition... implies that testing is a destructive process, even a sadistic process..."

 Glenford Myers, The Art of Software Testing, 1979





"If the objective of testing were to prove that a program is free of bugs, then not only would testing be practically impossible, but it would also be theoretically impossible."

 Boris Beizer, Software System Testing and Quality Assurance, 1984





"A tester is given a false statement ('the system works') and has the job of selecting, from an infinite number of possibilities, an input that contradicts the statement."

 Brian Marick, The Craft of Software Testing, 1995





"There are two distinct goals of a test: either to find failures, or to demonstrate correct execution."

 Paul C. Jorgensen, Software Testing: A Craftsman's Approach, 1995





Two types of testing should take place.

- 1. We must test to prove that the problem specified was programmed.
- 2. We must test to learn whether the program works correctly.
- Dennie Van Tassel, Program Style, Design, Efficiency, Debugging, and Testing, 1978



"Testing is done to find information. Critical decisions about the project or the product are made on the basis of that information."

 Cem Kaner, James Bach, Bret Pettichord, Lessons Learned In Software Testing: A Context-Driven Approach, 2002



CHECKING is a process of CONFIRMATION, VERIFICATION, and VALIDATION.

TESTING is a process of EXPLORATION, DISCOVERY, INVESTIGATION, and LEARNING.

Michael Bolton, 2009





Trish Khoo @hogfish · Sep 27

Wow okay when I asked developers this question I didn't get many replies on Twitter. Was I too scary? 😕 There's no wrong answer here, I'm just interested in different perspectives.

Help me out here devs, I know you're out there!

Trish Khoo @hogfish Testers, how would you answer this question? "What do testers do?"

And I'm looking for real answers, not joke answers. 🙂



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Trish Khoo @hogfish · Sep 28 Top tester answer: Gather information (in 31% of responses). Doesn't appear in any developer response.

Top developer answer: Work towards the team goal (in 32% of responses). Doesn't appear in any tester response.





Business Facing



Technology Facing

• Brian Marick, 2003



INVESTIGATION DISCOVERY

"There are known knowns. There are things we know we know.

We also know there are $\underline{known unknowns}$. That is to say, we know there are some things we do not know.

But there are also <u>unknown unknowns</u>, the ones we don't know we don't know."

 Donald Rumsfeld, US Secretary of Defense, 2002



INVESTIGATION IN DISCOVERY

"It is very difficult to find a black cat in a dark room," warns an old proverb. "Especially when there is no cat."

 Stuart Firestein, Ignorance: How it Drives Science, 2012

ILLUSTRATION: ROBERT NEUBECKER



INVESTIGATION DISCOVERY

"I know that this view of scientific process – feeling around in the dark, bumping into unidentifiable things, looking for barely perceptible phantoms – is contrary to that held by many people, especially by non-scientists."

Stuart Firestein



SOFTWARE INVESTIGATION

THE ART OF SCIENTIFIC INVESTIGATION

An entirely fresh approach to the intellectual adventure of scientific research

1950

1980

SEEDS OF DISCOVERY

The logic, illogic, serendipity, and sheer chance of scientific discovery



William Ian Beardmore Beveridge



SOFTWARE INVESTIGATION

A SEARCH FOR NEW KNOWLEDGE

DIS - COVER

Scientific research is not itself a science; it is still an art or craft.

- W. H. George

Oct-18



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ATTRIBUTES

- Pioneering attitude
 - Adventurous
 - \odot Prepared for difficulty
 - \circ Tenacious
 - \odot Independent thinker
- Insatiable curiosity
 - Dissatisfaction with what is known

- Sometimes difficult
 - \odot Lack confidence in their own views
 - \circ Skeptical of others' views

The most successful scientists are capable of the zeal of the fanatic but are disciplined by objective judgment of their results and by the need to meet criticism from others.



PREREQUISITES

- Willingness to work hard
- Intelligence
- Internal drive
- Imagination

It is not the talents we possess so much as the use we make of them that counts in the progress of the world.

- Brailsford Robertson



ETHICS

- Give credit to whom it is due
- Give generously
- Report sincerely
- Avoid secrecy

In the long run it pays the scientist to be honest, not only by not making false statements, but by giving full expression to facts that are opposed to his views.

F. Cramer



DISCOVERING DISCOVERERS

- Attributes of a good investigator are difficult to evaluate
- There is no exam
- Provide opportunity to demonstrate

Ordinary examinations are not a good guide to a student's ability at research, because they tend to favor the accumulators of knowledge rather than the thinkers.

- W. I. B. Beveridge



PREPARATION

SELF-DIRECTED LEARNING

- Knowledge
 - Build a foundation
 - Keep current
 - Maintain independence
 - Cultivate diversity
 - Understand history
- Skill
 - Tools
 - Methods

Fluency

- Communicate & think with clarity
- Confer
 - Participate in the greater community

The research worker remains a student all his life. Preparation for his work is never finished for he has to keep abreast with the growth of knowledge.



SELECTION

CHOOSE YOUR OWN WORK

- Interest encourages success
 - If work is chosen for you, seek out an aspect that provokes interest
- Select work that
 - has a chance of success
 - Is within your technical abilities

Start with a problem in which there is a good chance of [you] accomplishing something, and which is not beyond [your] technical capabilities.



SEQUENCE

ITERATE

- 1. Review
- 2. Observe
- 3. Analyze
- 4. Guess
- 5. Experiment

I do not believe such a thing as *the* scientific method exists, nevertheless, there are procedures commonly used in research."

- W. I. B. Beveridge



HYPOTHESIS

A TOOL FOR DISCOVERY

- Suggests new
 - Experiments
 - Observations
- Helps provide significance to what we observe
- Most will be wrong
 - Be prepared to abandon them

In science the primary duty of ideas is to be useful and interesting even more than to be 'true'.





EXPERIMENTATION

NULL HYPOTHESIS

Men who have excessive faith in their theories or ideas are not only ill-prepared for making discoveries; they also make poor observations.

- Claude Bernard



EXPERIMENTATION

TWO TYPES OF INVESTIGATION

Observational

 Collection of data from naturally occurring phenomena

Experimental

 Collection of data from an event made to occur under controlled conditions

A basic concept ... is that there is an infinitely large, hypothetical population of which the experimental group or data are a random sample.

All investigation is sampling





EXPERIMENTATION

EXECUTION

- Start modestly
 - Pilot
 - Sighting
 - Screening
- Take notes
 - Document as you go
- Iterate
 - Design later experiments based on results of earlier ones

Stop

- Be competent
 - Techniques
 - Tools
 - Subject

It happens surprisingly often that one needs to refer back to some detail whose significance one did not realize when the experiment was carried out.





IS NOT SCRIPTING

Discovery is unforeseen

 Infrequently comes from systematic accumulation of data

The research worker ought not, having decided on a course of action, to put on mental blinders and, like a cart-horse, confine his attention to the road ahead and see nothing by the way.





PLANNING

LEVELS

• Tactical

- \circ Performed by the individuals doing the work
- \circ Short term
- \circ One experiment at a time

• Strategic

- \circ Performed by a larger group
- Longer term

• Policy

- \circ Set priorities
- \circ Allocate resources

Discussions on planning research are often confused by failure to make clear what is meant by planning.

- W. I. B. Beveridge





ALL PLANS ARE TENTATIVE

- Plan with an appropriate level of detail
- Adapt to discovery
- Communicate deviations from expectations
- Planning is iterative

All plans must be regarded as tentative and subject to revision as the work progresses.

- W. I. B. Beveridge





PRODUCTIVE THINKING

- Conjuring up ideas happens to us
 - May come during
 - directed thinking
 - daydreaming
- Fertilize your imagination
 - Variety of knowledge and experience
 - Focus thinking
 - Stay curious
- Temporarily suspend judgment
- Use reason to make ideas useful

To be genuinely thoughtful, we must be willing to sustain and protract that state of doubt which is the stimulus to thorough enquiry...





CAN BE DANGEROUS

- Don't repress it
 - Risk going astray
- Balance it
 - Criticism
 - Judgment

What merely annoys and discourages a person not accustomed to thinking ... is a stimulus and guide to the trained enquirer.

-Dewey

Your brainchild is most likely not viable

- Check your work
- Detect and correct mistakes quickly



GETTING UNSTUCK

Temporary Abandonment

Let it be

 Return once old thought associations are less strong

In research most of the time progress is difficult and often one is up against what appears to be a "brick wall".



GETTING UNSTUCK

Talk it out

- Escape conditioned thinking
 - Explaining a problem requires clarifying information
 - Questioning by others disturbs our lines of thought

Productive mental effort is often helped by intellectual intercourse.



INTUITION

STAGES

- 1. Collection
 - Possibly relevant
 - Interaction
 - Friction and conflict
- 2. Contemplation
 - Multiple points of view
 - Associations
 - Work backwards
 - Discuss
 - Heuristics

3. Conception

- Connections
- Gut feelings
- Tacit knowledge

4. Criticism

They are ill discoverers that think there is no land, when they can see nothing but sea.

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<u>CHANCE</u>

THE ROLE OF CHANCE

- Chance plays an important part in discovery
 - Chance alone does not discover
 - Chance provides opportunity to the keen observer
 - Significance comes from an observer relating observations to other knowledge

In the field of observation, chance favors only the prepared mind.



CHANCE

COURTING CHANCE

- Prepare your mind to recognize useful information
- Entertain ideas that contradict beliefs
- Be unconventional
- Maximize the risk of having a fortunate accident
- Postpone demand for evidence
- Perform many experiments

Chance favors only those who know how to court her.

- Charles Nicolle



<u>CHANCE</u>

RECOGNIZE & EXPLOIT

- Be alert for the unexpected
- Don't be blinded by your hypothesis
 - Follow up on interesting side-issues

Acute powers of observation are often required to notice the clue, and especially the ability to remain alert and sensitive for the unexpected while watching for the expected.



OBSERVATION

EFFECTIVE OBSERVATION

1. Notice something

- \circ Things of interest
- \circ Changes in the familiar

2. Assign it meaning

 \circ Relating it to something else

What is observed depends on who is looking.

- W. H. George



OBSERVATION

DELIBERATE OBSERVATION

- Explicitly look for expectations
- Keep watch for the unexpected

Effective scientific observation also requires a good background, for only by being familiar with the usual can we notice something as being unusual or unexplained.





SATIR INTERACTION MODEL





The **common eye** sees only the outside of things, and judges by that, but the **seeing eye** pierces through and reads the heart and the soul, finding there capacities which the outside didn't indicate or promise, and which the other kind couldn't detect.

- Mark Twain



EUREKA

- Reproduce it
- Look at it from multiple perspectives
- Connect it with other knowledge
- Seek new avenues of investigation

The real and lasting pleasure in a discovery comes not so much from the accomplishment itself as from the possibility of using it as a stepping stone for fresh advances.





LIMITATIONS

Logic has very little to do with discovery or invention

- Logic builds on what is already thought to be so
- Discovery often requires disregard for current beliefs

Great discoveries have been made by means of experiments devised with complete disregard for well accepted beliefs.

-W. I. B. Beveridge



REASON

SAFEGUARDS

- Don't confuse interpretation with results
 - Recognize that generalizations cannot be proved
 - Don't place excessive trust in generalizations

Research is fundamentally a state of mind involving continual reexamination of doctrines and axioms upon which current thought and action are based. It is, therefore, critical of existing practices

Theobald Smith



REASON

REASON SUPPORTS

- Judging ideas conjured up by imagination and intuition
- Planning experiments
- Deciding what observations to make
- Assessing the evidence
- Interpreting new facts
- Making generalizations
- Identifying applications of discoveries

Although discoveries originate more often from unexpected experimental results or observations, or from intuitions, than directly from logical thought, reason is the principle agent in most other aspects of research and the guide to most of our actions.

W. I. B. Beveridge







STATISTICS

- People give numbers more credence than they deserve
- Averages are often misleading
- Graphs are often misleading

The use of statistics does not lessen the necessity for using common sense in interpreting results, a point which is sometimes forgotten.





MISLEADING EXPERIMENTS

Mistakes

- "Honest" mistakes
- Incompetent experimenters

Contamination

 Accidental or unknown influences

 Difficult to prove a negative Experimentation, like other measures employed in research, is not infallible.

Inability to demonstrate a supposition experimentally does not prove that it is incorrect.



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