Teaching and Learning by Way of Failure?

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ABSTRACT

From our earliest days, we learn through trying and failing. Early on, this is the natural way of learning. An unexpected and blatant failure has a large, possibly traumatic, impact. So why not conscious inclusion of learning from failure in education: testing, trying, and experimenting, transferring experiences between different domains of knowledge? How may such education, with an emphasis on learning results, be designed?

Teaching and Learning by Way of Failure?

Let me start on a personal note. The two most rewarding lessons I had during my four years of basic academic education were not any *intended* lessons, but results of professors' very much unintended failures. In the first instance, the professor, a recognized authority, obviously felt very sure of himself when he to his basic book for a particular branch of physics had added some newly discovered phenomena requiring fairly advanced mathematics to explain. We, three eager and ambitious students, freshly taught in such mathematics, spent an entire weekend trying to understand how he had applied it in this case: we could not work it out, and we went to the international literature on the subject. Eventually, we arrived at an explanation. Our professor knew the outcome as per that international literature, and he had, to arrive at the right outcome, committed several mistakes that cancelled each other out. We, the students, had finally arrived at the correct route for obtaining the same result. One of us argued that the professor should be, well, impeached (or whatever, left to the yellow press: my friend was profoundly upset and red with anger). None of us was happy with the lost time, but in retrospect, I do not regret it: we learnt something about not trusting authority too much, and we sharpened our working independently on a tough problem.

Next instance: in another field of physics, a new teaching laboratory had been established, with new exercises and experiments employing brand new instruments for advanced and topical measurements, intended to demonstrate advanced physics of a particular type (nuclear physics), reduced to practice. Novel, new is the key word here, novel as in untested: my colleague and I constituted the first group of two to run the gauntlet through all these novelties; we became the guinea pigs and also the troubleshooters, because nothing much worked as it had been designed or expected to. Electricity did not come on, or it went through our bodies, all by chance. Instruments measured something else than what had been intended. In fairness, the professor and his assistants showed us immense gratitude, and gave us good grades, which we had qualified for, though in a way inadvertently, forced to; not by design. In a way, this experience ties in with what EJ Langer[2] suggests in a wonderful book on mindful thinking and learning.

No educator had planned for these failures – to the contrary; those failures were instances of shame. But we, the students, learnt, even if in a painful and stressful way, though we discovered the unforeseen, unintended lessons only afterwards. Learning from these instances of truly efficient learning: how might failure based teaching, failure induced learning be designed and orchestrated?

I am not at all sure of how to apply these lessons to teaching but I would like to suggest and discuss, if not full-scale curricula, at least teaching (= learning) elements and ideas based on learning from failure, from mistakes – and from experimentation with an open mind. Failure can indeed serve as an eye-opener. (Does failure equate with mistake? Not always; for more synonyms, see the appendix.)

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[2] Langer EJ, 1997. The Power of Mindful Learning. Reading, MA: Addison-Wesley.

Some putative lessons

In my first case of experience, in a series of induction steps, one step introduced an error, and later, since the writer going through these steps already knew the correct outcome, he compensated for his first error with another error again. So one way of teaching can be to tell the starting point of a procedure and let that procedure land in a correct conclusion, while obscuring the correct process with faulty steps. The students' tasks, then, will be to find the errors and provide a corrected process (or perhaps several alternative faulty processes: which of those should be judged 'best' or 'most elegant'?). Sometimes it may prove productive to allow for a limited period of time to complete this task.

In the second case, we may protest that there was no outright failure, just a prematurely launched, incomplete setup. Our, the students', learning experience arrived from completing and implementing the intended design. So the obvious emulation of this episode would be to make the drawing for some design, get the components together, and then challenge the students to produce a complete, working design (well, the task could well include choosing components from an assortment of such). Again, a deadline may add to the discomfort or challenge – and the learning outcome.

A mentally more demanding variation to this would be to refrain from getting all (the right) components together but leave some out, possibly with some false starts added. Students would be told of the impossibility of completing the task, and also charged with the challenge to make an incomplete or somewhat faulty 'end product', explaining how they judged different trade-offs. Here the time element might again be introduced as one variable in the decision process, and competition allowing for learning from seeing the effects of different perspectives, choices, and priorities brought to bear.

Students themselves may also be tasked with these endeavors. One task may be to construct a 'false proof' for others to correct. Again a deadline may well add to the challenge. Likewise, we may ask them to assemble an incomplete set of components associated with some intended design, incompleteness the main point in provoking different cases of graceful failures.

Mindful habits

Mindfulness is one key habit, so students should be inspired to describe, reflect on, and analyze their experiences from failures. What do they experience? What are their conclusions, the lessons learnt? How can these be translated into future practice and transferred to other domains of knowledge and competency acquisition?

The same may apply to reflections on failures, mistakes, errors in a student's life. Of these three concepts, which one(s?) would apply?

A failure diary would annotate failure, mistakes, errors mentioned or highlighted in current news, reported in the media.

Students may be induced to compete on 'best failures' (what should that mean, then?), most interesting or rewarding such reports, suggestions for ways to treat or salvage failure situations. The task may also be posed upside down: the 'worst' (again, how to judge, measure, what metrics?). By the way, what metrics for *comparing* failures? How best reward them? The latter is also a question for students to elaborate on. Students are sometimes encouraged to identify role models, to learn from and to emulate. What about failure models also?

In a management setting, failure analogs to traditional concepts could be pondered profitably. What would be the (productive) tasks of a Chief Failure Officer? How might failure be reflected (positively) in performance reviews, salary development, and c v:s? How might Return on Failure, ROF, be calculated or maybe just indicated superficially? May we arrive at a failure profit and loss tabulation, a failure balance sheet, where these can be followed from one period to the next.

For a corporation, a fundamental question might be how to maximize profit or return on capital. If that is the goal, how to judge success or failure? Or the objective may pertain to optimization, with the same question.

Herbert Simon suggested the term and the aim of satisfying, establishing a critical hurdle to pass, something which makes for an answer.

A large company once bet its future on extending, extrapolating its existing technology in an incremental way. The result was such a shattering failure that the company seemed doomed: a crisis loomed. Only starting afresh, abandoning established wisdom and huge investments opened the way for a risky and uncertain gamble -- that became an enormous success. So one might attempt to define the *quality* – qualities – of failure. How informative is it, how convincing? May a crisis turn out to be helpful, productive?

Choose failures from the failure collection or the failures museum (searching for 'failure museum' with Google gives easily half a dozen results with different slants), and ponder and discuss them. How may, e g, failures of a political nature inform failures in physics or mechanics, and vice versa?

For much of the 19th century, Bach was considered a minor composer, with no impact and a production of little value. At first, Picasso turned "Les Demoiselles d'Avignon" towards a wall; he took his friends' advice that it had little value, was a failure. Much later, Picasso expert J Berger subscribed to the same opinion. Whereas H Gardner in his book on creative genius[3] suggests that it is one of the emblematic masterpieces of the 20th century. Who decides on what constitutes a failure, and why? Why that *who*, and why the who's judgment?

Rating student merit on failure, how may that work out? This conundrum is akin to how creativity may be taught and rated. One result may be seen as placed in the process, in the student's subjective experience. For creativity, fluency (frequency of new ideas), flexibility, elaboration, and originality (ideas being fundamentally dissimilar, not just variations on a theme) have been suggested (and indeed used) as foundations for a metrics (developed and tested by EP Torrance, who tampered with his metrics repeatedly). If translated into the realm of failure, this could inspire looking at how much the failure is off the intended mark, and originality when it comes to learning experience.

How might university organization be affected by implementing learning from a failure curriculum? A *study director* for efforts, experiences, experiments in failure learning? What would be the design and equipment of its failure laboratory?

A sampling of failures

Below will follow a number of suggestions on how failure might be brought to bear on education/learning. One obvious suggestion is testing whether learning from failure in one particular domain may be transferred to others.

Michelson-Morley's attempt (in the late 19th century) to measure the ether wind came, famously, to naught. Einstein arrived at the explanation. Poincaré solved the three-bodies problem by proving that it is fundamentally impossible to solve. In the process, he discovered chaotic behavior, another general circumstance resulting in the futility of particular efforts, thus resulting in failure unless chaos is taken into account and allowed to circumscribe what may be attained. These are examples of 'compulsory' failures, and students may be challenged to add to the list and to discuss the lessons and possible generalizations. In such a list, classic mathematical problems like the trisection of an angle might be included. The laws of thermodynamics are formulated as failures in making perpetuum mobiles of different kinds, and Gödel's incompleteness theorems are (in a lay description) about the impossibility of, the failure in proving something within its own frame of reference.

One of many partial synonyms to failure, partial but not an exact double, is error. Error is also most often domain dependent and there is the argument about the effect of good feedback. Yet another synonym would be fault as in fault tolerance, the latter implying robustness, possibly linked to redundancy (and even Taleb's anti-fragility[4]).

[3] Gardner H, 1993. Creating Minds. New York, NY: Basic Books.
[4] Taleb NN. 2012. Antifragile. New York, NY and London: Random House and Penguin

The *learning* ('organizational learning') behind the Horndal effect (the 'burning in' of a new process in an organization) and the one integrated in the procedures in Japanese (and now other) companies starting to produce a new product, allowing, even encouraging everyone along the line experiencing a bug in the product to stop the line and raise the alarm so that the fundamental source of failure might be eliminated, once and for all. 'Lean production' equates with no material buffers, and thus high sensitivity to deviations (another part-synonym). For many products, certainly electronic ones, there is a 'burning in' after which functioning is smooth. 'Six sigma' is nowadays an established way of expressing a level of statistically defined maximum deviations from a norm (fault tolerance to a degree, if we wish), also pointing to the vista of statistics in the striving for reducing error. A cardinal problem here is the limits to statistics, the risk of being 'fooled by randomness' (Taleb[5]). Thus the normal distribution might be a mirage and, e g, a Bayesian approach necessary.

The 'Japanese' gearing up production method is failure as information production. In what other ways may failure become productive; what types of information, perhaps experiences might it generate? How to best organize for a positive result, on the individual, organizational, or societal level?

A digital system is inherently less error prone than an analog one, because rounding errors are eliminated. There may also be a check digit.

Then there are systems that really have to be fail-proof: think nuclear reactors, think passenger jets: they can never be allowed to fail. What can be learnt from precautions and actions intended to guarantee their reliability? In addition to backups and redundancy, there is concern for the abilities of the human operators involved. One source to failure may be information overload, another uncomfortable, indeed faulty, mistake-inducing man-machine interfaces. Well over 95 per cent of all helicopter crashes stem from the (in-)famous 'human factor'. There is an entire discipline dedicated to safety concerns and man-machine interaction. What may be learnt from that failure avoidance corpus for, e g, *man-man* interactions? What is the counterpart to the user interface here, and how may it be improved upon?

Thinking traps

Kahneman and Tversky, pioneers in economic psychology, have mapped a number of possible heuristics to reduce the risk for failure, but also intuitions and thinking traps that do us great disservices (Kahneman's book on fast versus slow thinking[6] had a forerunner in Piatelli-Palmarini's popular summing-up[7] of the Tversky-Kahneman findings). In many situations we need to take into account probabilities for example, and here intuition often leads us astray. How may heuristics that make us smart (Gigerenzer's phrase[8]) be developed and established?

Some art is geared at deceiving the eye, 'trompe l'œuil', thus pointing to shortcomings in our perception. Likewise, cognitive psychology provides ample examples of deceptive mirages.

Intuition may be context dependent in another way as well. When Europeans arrived to the foreign continent of Australia, some of these colonists, with artistic or documenting ambitions, tried to capture the new environment in sketches or paintings. Today, many of these renderings look decidedly odd. Until one realizes that they are the result of people looking with a framework of European nature, unable to truthfully capture their new and different environs. Let this failure in perception give pause: in what other ways may we get into similar traps, in which fields of learning and training. Seeing represents one faculty – might the same phenomenon apply to others?

Intuition and (often convincing) arguments are frequently underpinned by proverbs – but a study of a large corpus of proverbs reveals that many of them contradict each other. Likewise analogs and metaphors may be applied far away from where they would be reasonable.

[5] Taleb NN. 2001. Fooled by Randomness. New York, NY: Random House and Penguin
[6] Kahneman D, 2011. Thinking Fast and Slow. London: Allen Lane.
[7] Piatelli-Palmarini M, 1994. Inevitable Illusions. New York, NY: John Wiley and Sons, Inc.
[8] Gigerenzer G et al., 1999. Simple Heuristics That Make Us Smart. Oxford and New York, NY: Oxford University Press.

We have met a number of failure examples from the domains of technology and physical production. How might they or the 'learning from correcting a faulty proof or adjust and trim an experimental setup' be translated into other fields of learning: languages, literature, the humanities in general, social services, service production? Translation requires the acceptance of a degree of failure in the sense that there can never be a one-to-one correspondence. A comparing of different translations, nay, interpretations of, e g, classic Greek poetry or drama might generate a productive discussion, again about how what is judged as 'more' correct is dependent on context or even individual taste. Hofstadter's "Le Ton Beau de Marot"[9] is a great exposition of what *interpretation* may entail.

We learn language, not least our mother tongue, through failing (though not *only* by way of failures).

The Chinese whispers game and the impossibility of exact translation, interpretation only, make for yet more discussion of how to judge quality, the more or less correct rendition of an original, and, again, how it may be context dependent. Different renderings for different audiences, situations, times? How may auditory regularities like rhythm and rhyme make for a more exact replicating of myths, tales, and what, more generally, the viral quality of *memes*? How may rhythm and rhyme be distorted, and distortions so attractive as to become misleading? How may fake answers and propositions, not to speak of art, be spotted? When can faked or falsified art be deemed successful and when a failure? Can it serve as a springboard for something positive, such as a mistake does in improvisation, in music and theater?

What causes a bubble, financial or in real estate? What kind of failure is that, and how may it be prevented or its effects moderated? May the bubble effect be found in other vistas of life, in art, culture, or human relations? Not just indirectly, on the money side, as with the Dutch tulips in the 17th century or different types of art? Bubbles may be seen as the short term besting the fundamentals and the long term, at a stiff price. Bubbles are also about perceptions, belief, and herd behavior. May there exist other failures resulting from too heavy weight on the short, the mid, and/or the long term? These terms: on which scale, individual, organizational, society, family, clan, or perhaps nation? All of mankind, or our natural habitat?

A moment ago, we met the much debated concept of memes. Created by R Dawkins as culture's equivalent to genes[10], they are seen as evolving and taking hold through broadly the same process of evolution: mutation, selection, procreation. (Proverbs may serve as one example category.) In a sense, the Darwinian evolution is an error correction process – screening out failure – where fitness and lack of disadvantages may be seen as criteria for success. Then the 'Red Queen Effect' and co-evolution makes success only ephemeral.

Limits to failure

If you break the record in high jump, that would be success. Then the rib is raised to the next level -- and you fail at the new record height. Failure?

Future studies can well be seen as a field where failure may be welcome or at least frequent: 'welcome' when a study results in self-destruction (the opposite to self-fulfilling) of a threatening negative future development. Anyhow, most studies can only at most be expected to be partially successful, thus part failures. May such guarded expectations hold for other fields?

Words like failure or mistake are quite often employed in politics – domestic, international, office, or doctrinal. Can we learn from it; perhaps important lessons might emerge out of discussions on the meaning of failure in this context. Or metaphors or analogs maybe mistaken in that they mislead in ways that can be costly. The economist may protest, but the same argument maybe applied to 'the dismal science'.

A novel, a poem, a movie may fail in the sense that the author's or the director's message does not get through. Perhaps there is economic success nonetheless – some failure in that case! The book, the film, the theatre play set up may fail economically, regardless of whether it fulfills the originator's artistic ambitions. According to legend, Stravinsky's "Rite of Spring" was thoroughly thrashed by the première public.

[9] Hofstadter D, 1997. Le ton beau de Marot. New York, NY: Basic Books.
[10] Dawkins R, 1976. The Selfish Gene. New York, NY: Oxford University Press

Can you ever succeed in explaining, interpreting a dream? Did Freud ever fail – or succeed? Can one really fail at a task where there is no litmus test to tell the veracity? Often convincing, yes. So a discussion on how to design and construct such a test, or in what situations it is fundamentally impossible, would contribute to the development of a framework for what limits there are to a fail--success dichotomy.

Convincing was the term. So, again, a question of belief. A religion may fail to attract believers, or to make those attracted failing in heeding its commands. Here we see failure as something applied within a system, a belief system.

Failure sources to benefit from

There is a web site for "FailArmy" which in Youtube format chronicles failures. Some are to be laughed at, others not – they are to learn from. Which category depends on the viewer, so something to discuss. Criteria, take home lessons? TED hosts a number of enlightening talks touching upon failure – J K Rowling's on Youtube is an outstanding one.

The "IgNobel" prizes are awarded for odd scientific discoveries. Their motto is to make you laugh but then to make you reflect, understand, thus to learn. The hosts for this event also issue the periodical "Annals of Improbable Research", on the same general theme. The web journal "Edge" poses an annual question to its think tank of science geniuses, a fundamental question such as what would change the worldview. The "Skeptic" chronicles failures, deceptions purportedly on a scientific foundation*.

Furthermore, there is the Mistake Bank which issues frequent e-mails on that subject matter, and B Kanter curates a "Scoop.it!" on "Failure and Learning".

Our students should be provoked. If not, we have failed.

Appendix: Synonyms galore

Failure, mistake, error – there are several partial synonyms to address the same broad concept. They have different connotations from seemingly less negative words like experiment, test, trial/try, learning, experience. And they may take on different flavors, like in fault or defect or imperfect, inability, accident, aberration, or sub-standard or abnormal. Imperfect, aberration, and abnormal are examples of negations to the ideal, as are inadequate, incoherent, absurd, impossible, inappropriate, beside, miss, useless; the list may be made longer, also including erratic, out-of-order, unacceptable, weakness, lapse, infirmity, erratum, erroneous, inadvertent, incompatible, malformation, departure (from), misconception, wrongful/wrong, disproven, broken. Obsolescent indicates a failure *quality* as does redundant, unnecessary, decaying, and impermanent, ugly an esthetic one. – Catastrophe, of course, is the worst failure conceivable or experienced. A crisis may result, as from failure also.

*The Skeptic: (our) mission is to engage leading experts in investigating the paranormal, fringe science, pseudoscience, and extraordinary claims of all kinds, promote critical thinking, and serve as an educational tool for those seeking a sound scientific viewpoint.