Inspiring a Solution-Oriented Attitude to Laboratory Trainees

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Introduction

Conducting experiments is often a new experience to laboratory trainees. This involves several challenges; for example, they need to perform activities and think in a way they have not done so previously. But since science is about discovery of new knowledge, they often need to perform activities and think in a way no-one has done so previously. Approaching such an endeavor is a daunting task, and usually two types of research personality emerge: problem-focused and solution-focused. Individuals in the former group see problems, real or perceived, as insurmountable obstacles that should be avoided, even if this means inevitably avoiding to do ground-breaking research. The latter act in a constructive and often creative manner, seeking solutions and going ahead, learning—without being detracted—from failure. With a focus on practical, experimental lab-work, this reflection will draw from my experiences in the laboratory as both trainee and group leader, and relevant pedagogic literature, to discuss how to develop the next generation of problem-solving scientists.

Problem-focused and solution-oriented: two opposing attitudes in science and other fields

The Spanish word problemático has some interesting differential meanings. On one hand, it is similar to problematic in English, meaning a troublesome situation or referring to a person who causes problems. A third meaning describes a person who focuses on problems and is strongly hampered by them. This meaning does not have a straightforward equivalent in English, but it is closer to a ‘naysayer’ than a ‘troublemaker’. Another way to describe this is “problem-focused”. In a very simple example, a problem-focused response to a new endeavor would be to point out all things that can go wrong and why the methodology is pre-determined to fail. A problem-focused person may oppose an undertaking either directly (refusing to proceed), or indirectly, by not dedicating the commitment required to problem-solve and forge ahead.

Intuitively, the antonym of problemático, i.e., “solucionático”, refers to a person who focuses on achieving a goal despite any anticipated problems—i.e., solution-oriented. A solution-oriented approach to a new endeavor will be to acknowledge that problems do exist (or may arise in the future) but nevertheless keep pursuing the goal with some solutions already at hand (or with confidence that solutions can be found). Solution-oriented people are committed to completing the undertaking and deal with shortfalls constructively. They see problems as merely temporary setbacks or even as opportunities to improve the outcome.

Interestingly, “solucionático” does not exist in the Spanish dictionary. The two antonyms are more commonly used in the South American part of the Spanish-speaking world, in journalistic articles, commentaries and editorials, to describe people from football players to politicians, often lamenting the lack of a soluciónático, both as a word in the dictionary and as a namesake person. They were made pertinent to the practice of science and medicine by Dr. Bartolomé Finizola Celli, the pioneering Director of the Cardiovascular Program of Lara State, Venezuela. His brief opinion piece in the Venezuelan newspaper El Universal is particularly illuminating on these concepts (Finizola Celli, 2019).

I was introduced to these terms by a Chilean professor, who used them to describe scientists, and I remember being struck by how perfectly either can describe certain members of my profession. The two concepts are highly pertinent to the daily conduct of experimental science because the occurrence of problems is an innate challenge of this profession, and a great portion
of time is taken to anticipate and solve them. Finally, they are important concepts to address in the context of research supervision because their meaning goes beyond merely having a pessimistic or an optimistic attitude; they pertain to how one may conduct oneself as a scientist. Therefore, imparting a solution-oriented approach to experimental science should be an integral part of the training of next-generation scientists.

The occurrence of problems in scientific practice

To perform laboratory-based science is to deal with problems, both intellectual and practical. It is perhaps intuitive, that the process of making a discovery—a scientist’s principal professional goal—will likely involve encountering and solving problems that prevented other scientists from making that discovery first. Aphorisms such as: “all easy experiments have been done already” abound in the lab. A more concrete piece of evidence for the certainty and eminence of problems in research is the requirement, from both national and private funding agencies, that scientists should clearly state anticipated problems in their grant applications.

Importantly, research problems are largely new to research students. Student-scientists may come from a classroom (or equivalent) environment, where knowledge is but a few page-flips or keystrokes away, and problems are largely academic and contained within a well-defined course syllabus. Their transition to the laboratory can be a shock, as technical problems may ruin a crucial experiment, throwing a wrench in the works of a carefully-thought-out plan. Certainly, parallels can be drawn with arts-and-humanities doctoral education, where candidates may pursue a research passion close to their own identities and personal circumstances, outside the confines of a library or laboratory. And while it could be argued that a STEM education offers a more structured environment by comparison (Carter & Gunn, 2019), I propose that learning laboratory science can also be “potent, subversive and messy” (to use the words of Carter and Gunn), precisely by virtue of its pesky problems, which may require creative, desire-driven work to circumvent.

Negative experiences are formative, and can impart a pessimistic, cynical, or otherwise “problemático” (problem-focused) attitude to the trainee. The obvious outcome is that the student may hesitate or completely object to attempting to solve the problems associated with an experiment, citing previous failure. During my career, I have (i) met several senior problem-focused scientists; (ii) witnessed the evolution of problem-focused attitudes in students, and, most certainly, (iii) been a problem-focused person myself. Yet, while inevitable problems, unforeseen roadblocks and sudden pitfalls can definitely be intellectual and practical nuisances, solving them is one of the greatest satisfactions of my profession. Strategies to inspire an optimistic, solution-oriented attitude in research students are discussed below.

Elements of research supervision crucial to imparting a solution-oriented attitude

What elements of research supervision are most central to the development of “solucionático” scientists? In their “professional work” theory of doctoral supervision, Halse and Malfroy (Halse & Malfroy, 2010) propose that research supervision encompasses five facets: the learning alliance, habits of mind, scholarly expertise, techné, contextual expertise. Certainly, all facets are important for a successful supervision—that will in turn produce a successful PhD
graduate. Of the five, I suggest that habits of mind and technê may be the most pertinent for the topic of this reflection. First, the habits-of-mind facet, is defined as both a disposition and mode of behavior. It is related to Aristotle’s phronesis, or practical intelligence and wisdom, and it can be particularly critical in a laboratory setting, where one must act not only effectively, but also safely and ethically. However, the connection of habits of mind, or phronesis, to having a solution-centric attitude is perhaps a little tentative. For instance, it might be considered appropriate (“phronetic”) to dismiss a research goal in order to evade a perceived problem: a problemático course of action. By the same token, an overly optimistic approach with insufficient consideration of problems can be said to be lacking in phronesis. This is not to say that habits of mind and phronesis favor a problem-focused attitude; rather, I propose that they are best combined with another facet of research supervision identified by Halse and Malfroy, technê.

Technê relates to the Aristotelian concept of craft knowledge. It is “the creative, productive use of expert knowledge to bring something into existence or accomplish a particular objective” (Halse & Malfroy, 2010). It is critical to all scholarly work, but it is possible to intuit its special connection to experimental sciences, where technê refers not only to academic and intellectual skills, but also practical skills, closer to its original concept of craftsmanship. For example, a recognized skill in the laboratory practice of electrophysiology, which often involves fine tool manipulations, is having “good hands”. With regards to our topic, technê is very important, because knowledge of what is feasible can make the difference between diligent versus overt attention to problems, and reasonable versus unrealistic optimism for reaching a solution. In other words, while habits of mind / phronesis point towards the direction of research, technê determines how to get there. Their combination is an essential means of fostering a solution-oriented attitude, providing the ability to both identify and effectively pursue a worthy research goal.

Some practical strategies for instilling solution-oriented attitudes

How, then, to practically implement phronesis and technê in the lab to bring up solution-oriented scientists? I propose that the first step should be the acknowledgement that problems will occur, and that is okay. In his textbook on basic mechanics, Reif included a chapter to problem-solving, where he defined a problem as “a task leading from some initial situation to some specified goal” (Reif, 1995)—i.e., a matter of course in scientific education, not necessarily a negative challenge. In my opinion, recognizing that problems are bound to occur is the cornerstone of a solution-centric attitude; in other words, normalizing problems can be a constructive approach, similar to normalizing other negative, but inevitable and otherwise manageable, elements, such as uncertainty (Albertyn & Bennett, 2021).

In addition, an organized, structured approach to problem-solving can lay the foundation for fostering solution-oriented scientists. Pólya (Pólya, 1945) proposed four stages to problem-solving in mathematics, which can be transferred to other sciences as well: (i) understanding the problem, (ii) devising a plan, (iii) carrying out the plan, and (iv) looking back. Despite its apparent simplicity, this algorithm shows that the problem-solving process can be learned, and therefore does not differ from any other skills that can be acquired during doctoral education. This premise can be particularly enabling to novice scientists whose educational development may be hampered by self-doubt (Albertyn & Bennett, 2021) or the infamous imposter syndrome.
(Clance & Imes, 1978; Chrisman et al., 1995). That is, the more adept one is at problem-solving—a learnable skill—the more solution-oriented one will be in the future.

Established approaches to problem-solving can be part of the training plan, including breaking problems down, evaluating different options, using approximations or even seeking expert help; the list goes on (Leak et al., 2017). Problem-solving training can involve general principles or algorithms of problem-solving (Pólya, 1945), but also elements specific to the topic of doctoral education. After all, one cannot troubleshoot, for example, microscopy problems, without at least some education on microscopy. A more structured form of doctoral supervision, such as the Directorial or Contractual Styles, as defined by Gatfield (Gatfield, 2005), may be required to support the latter, early on during the PhD, as part of the student’s skillset (technê) development. While highly-structured supervisory styles require more supervisor time and resources, their pay-off, a solution-oriented PhD candidate with a well-developed skillset, is surely worth the investment.

Can failure be harnessed to build positive research attitudes? Failure (hopefully short-term) is an inevitable experience for research students and, by definition, will arise because of a problem. Successive, or long-standing failure may foster negative attitudes towards further attempts and engender a problem-centered attitude. Yet, a controlled form of failure has been proposed in higher education, which involves asking the students to solve a problem before they are taught about the central concept and procedures associated with that problem: a practice known as “productive failure” (Kapur, 2008). This approach, which actively encourages “struggle”, can be effective in, for example, the training of health-care professionals, who are expected to encounter problems in the clinic they were not taught about (Steenhof et al., 2019), and plausibly also has high potential for helping laboratory science trainees. However, I would counter that controlled success, rather than controlled failure, may be a more effective tool in fostering a confident, solution-oriented scientist. That is, guiding a student through “small victories” with well-defined, contained, short-term goals, would develop their technê and self-esteem, leaving them more capable and braver to take on bigger and riskier tasks. This can be initially directed by the supervisor during an early, hands-on supervision phase; but students can also be encouraged to pursue “small victories” by themselves when stuck in a rut. A great source of such practices are positive-control experiments. First, these are critical experimental procedures, ensuring that one’s equipment and reagents are adequate and in good condition for the task; and in addition, they may serve as “self-esteem boosters”, reassuring one that one’s own skills are in good order, dispelling any negative attitudes. If they fail, they should clearly indicate the item or practice at fault, assisting in the problem-solving process: a win-win scenario.

Summary

In summary, problems are a matter of course in any scientific endeavor, but scientists have two differential attitudes toward them, beautifully expressed by an unusual use of Spanish: problem-focused (problematico) or solution-centered (solucionatico) (Finizola Celli, 2019). A successful doctoral education will empower students with the confidence to take on worthy, risky research projects, without becoming discouraged by potential roadblocks and pitfalls. I propose that this can be particularly effected by the application of the Aristotelian concepts of phronesis and technê, i.e., habits of mind and know-how (Halse & Malfroy, 2010). Road-maps to these include normalizing problems, and teaching effective, structured means of problem-solving, to
both make students adept at dealing with problems, and boost their confidence of doing so in the future. Finally, I propose that controlled success (“small victories”, positive-control experiments), rather than controlled or constructive failure (Kapur, 2008; Steenhof et al., 2019), is an important tool in the supervisor’s armamentarium, to foster the next-generation solution-oriented scientists.
References:


