The 3Ps of problem posing, problem solving and peer persuasion — an elegantly simple model that portrays the overall flow of scientific research — has attracted many enthusiastic advocates, including myself. In fact, a 3Ps philosophy is an integral part of my current research on the development and pedagogical application of a model fora "flexible scientific method." Nevertheless, a few modifications of 3Ps may help develop a more accurate characterization of scientific research and a more effective tool for improving science education.

In previous discussions of 3Ps philosophies, it has not been clear whether the Ps refer to stages or activities, or both. Sometimes the existence of stages is implied. For example in Stewart & Jungck (1993, p. 10) refers to "stages of scientific practice" and a similar sentence appears in Peterson & Jungck (1988, p. 16). At other times, however, the 3Ps are described as activities.

This paper will explore the complex interactions between stages and activities by discussing posing, probing and persuasion as 3 stages, as 3 activities, and by making use of a 3 x 3 matrix (Figure 1), followed by a comparison of my "stages and activities" analysis with previous 3Ps formulations.

3Ps as stages
Imagine a research lab where scientists first plan what they will do, do it, and finally explain what they did and what it means. These are, roughly, the stages of posing, probing and persuasion.
1. In the posing stage, scientists thoroughly evaluate the current state of knowledge by critically reading (the observations, interpretations and conclusions of other scientists) and reviewing (what they think they already know); then they decide what to study and how to study it, and write funding proposals in an effort to obtain financial support.
2. During the probing stage, they "probe" the problem with the goal of constructing a solution.
3. In the persuading stage, scientists try (by writing, talking,...) to convince others to accept their solution to a problem.

3Ps as activities
A. During posing activities, scientists — by selecting a certain area of nature to study, and choosing the questions they will ask about this area — decide how to narrow the scope of a research project. The results of posing can take the form of questions to ask, or objectives to achieve, or (as in a 3Ps formulation) problems to solve.

B. Probing activities span a wide range, and include everything that scientists think will help solve a problem. These activities can be grouped in two basic categories: observation (plan and do experiments or field studies, make observations) and interpretation (organize data to facilitate pattern recognition, analyze and synthesize, use algorithms and heuristics, construct and evaluate hypotheses, review the observations and interpretations of others). Recurring cycles of observation and/or interpretation are completed and informed by evaluation-and-planning. In this ongoing evaluation of the current situation, "research gaps" (i.e. ways in which project-knowledge is incomplete or incorrect) often emerge that can serve as guides for the improvisational planning of additional probing activities that are designed to generate observations or assist in their interpretation. The goal of these activities is either to construct a possible solution, or to gather more support for a solution that has already been proposed. Eventually, the Investigators will decide that an end to probing is warranted because of a judgment that the problem has been satisfactorily solved, or that the search for a solution should be abandoned, at least temporarily.
C. The original 3Ps definition of persuasion does not include the self-persuasion that occurs, in individuals and within a research group, during the posing and probing phases; instead, it emphasizes the need for scientists to "persuade others of the value of their solutions" after the probing stage. It may be useful to broaden and clarify this definition in four ways: • persuading activity occurs at all stages of a project; • it includes persuasion of self and others; • it is critical of one’s own arguments and is receptive to the arguments of others; • its objective can be an evaluation of the extent to which an idea is worthy of either acceptance (as a part of scientific knowledge) or pursuit (as a project to investigate).

<table>
<thead>
<tr>
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<th>B. PROBING activities</th>
<th>C. PERSUADING activities</th>
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<td>3. PERSUASION stage</td>
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<td>3C. write articles for journals (or prepare talks for meetings) to persuade others that one's conclusions are worthy of acceptance (and that future projects are worthy of pursuit)</td>
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Figure 1. Interactions between the stages and activities of posing, probing and persuading.

This legend above examines each of the 9 boxes (1A to 3C) in the matrix that summarizes an interaction between the 3 stages (1, 2, 3) and 3 activities (A, B, C) of posing, probing and persuading. In Figure 1, each of the 9 cells represents an interaction between a stage and an activity; for example, the persuading activity (C) that occurs during the posing stage (1) is abbreviated "1C". As you read the descriptions of individual cells, remember that "the matrix as a whole" is the problem solving effort, and that the objective of this 3x3 model is not just analysis, but analysis-and-synthesis. 1C: during the posing stage (1), persuading activity (C). Critical evaluation, used creatively, is essential for finding a gap (a weakness in the current knowledge structure) that can serve as the focus for defining a scientific problem in 1A and 1B.

1A and 1B: posing stage (1), activities of posing (A) and probing (B). The scope of a research project is defined by decisions about WHAT to study (an area of nature, and questions about that area) and HOW to study it (how to make observations and interpret them: experiments to perform, methods of analysis,...). In 1B the main activity is planning for 2B, but there can also be preliminary studies or thought-experiments.

1C: posing stage (1), persuading activity (C). Posing a good problem — one that is original, interesting, significant and capable of being solved (within the practical constraints of the available knowledge, people, time, equipment and money) — is itself a formidable problem. But
just because a problem can be posed does not necessarily mean it should be pursued. Members of a research group, or prospective members, such as graduate students who are being recruited, must evaluate the potential of a project. Compared with other alternatives, and ask, "WHY should we be doing this?" They need to do this in order to persuade themselves, either yes or no, whether it is likely to be a wise investment of their time. Often there is also an attempt to persuade others, such as a funding agency, that the proposed project will be a worthwhile investment of their money or an ethical course of action to pursue.

2B-and-2C: probing stage (2), activities of probing (B) and persuading (C). The probing activities in 2B, described earlier in B, are an extension of the preliminary planning-for-probing that was done in 1B. Ongoing evaluation in 2C is the "guidance system" for the improvisational planning that controls the activities of observation and interpretation in 2B. Just as the focusing that occurs in 1A-and-1B can be viewed as the generation of a problem (trying to answer specific questions about one area of nature) from a mega-problem (an attempt by science to understand all of nature), evaluation-and-planning (in 1B, 2B and 3B) can be seen as a strategy for coping with this problem by generating practical sub-problem activities that are designed to contribute to its solution.

2A: probing stage (2), posing activity (A). Evaluation-and-planning can produce ideas for probing activities to begin immediately (as the 2B in a current project), or it can inspire "spin-off" ideas about how to expand the scope of questions being posed in a current project (thereby modifying its 1A) or about what to do later (as the 1A-and-1B for a future project).

3C: persuading stage (3), persuading activity (C). Written and oral arguments are used to persuade others that one’s own conclusions are worthy of acceptance.

3B and 3A: persuading stage (3), activities of probing (B) and posing (A). The process of persuasive writing requires precise thinking about the logic and adequacy of one’s own arguments. This self-critical evaluation can lead to a recognition of research gaps and the need for immediate pursuit (in 2B probing) or — if this seems unnecessary or impractical — for delayed pursuit (as proposed in the 1A and 1B of a future project). The evaluation-and-planning in 3B-and-3A is analogous to that in 2B-and-2A, but the evaluation is occurring at a later, more advanced stage in the research process.

3C: persuading stage (3), persuading activity (C). The primary objective of most scientific publications is "persuasion for acceptance" of one’s arguments, but there also can be other objectives. A common secondary goal is "persuasion for pursuit" — to convince others that one’s future projects will be worthy of support. Arguments for support are often subtle. They can be explicit, as when a paper concludes, "more research is needed." Or they can be implicit: simply "getting published" is an argument in favor of future support, due to the common assumption that if one’s past work has been significant — and one indication of this is publication in a reputable journal, which shows that the work has passed some type of peer review — then this makes it more probable that future projects will also be significant.

Compared with previous 3Ps formulations, my analysis differs in two ways: • there is an attempt to clarify the distinctions and the interactions between stages and activities; • my definitions of activities are narrower for posing, but broader for probing and persuasion. Each of these differences will be discussed.

Figure 1 (above) contains many overlapping interactions: some planning for 2B occurs in 1B and 3B; ideas for a future 1A-and-1B can be inspired in stages 2 and 3, with pilot experiments being run in a current 2B; and critical evaluation (the persuasion of self and others) is involved in everything! In addition to the temporal overlap of projects, with one beginning before another ends, often there will be conceptual and methodological overlaps between the various projects.
undertaken within a research group, plus collaborations that intertwine the work of many groups. These multiple overlaps do not necessarily detract from the value of a 3x3 analysis, because its goal is not to make everything fit into 9 neat boxes, any more than 3Ps tries to put it all in 3 boxes. Instead, the purpose is to provide a framework — an approximate model that can be used and evaluated, then revised and supplemented as necessary — for exploring complex stage-and-activity interactions; if these cannot be confined by a row or column or cell, then we can ask "why not" and "what are the actual relationships?" Hopefully, the creative thinking stimulated by these questions will lead to new ideas about 3Ps — about its structure and philosophy, and how it can be used to improve science education.

Many of the probing-stage activities in 2B-and-2C have previously been defined as posing. For example, "With GCK it is possible to pose problems about what hypotheses to draw from the initial data; which of several traits to pursue first; what cross to make first; how best to confirm or reject hypotheses; and when to abandon work (that is, solvers decide what constitutes a solution to a problem)." (Stewart & Jungck, 1993, p. 14; a similar list appears in Peterson & Jungck, 1988, p. 17) These questions can be interpreted as either the posing of sub-problems in an effort to solve a problem, or as probing in an effort to solve a problem. With the former interpretation, almost any question that could ever be asked can be viewed as problem-posing, and many useful distinctions disappear. But when viewed as probing — as observation and interpretation in recurring sub-goal cycles, with feedback and guidance provided by evaluation-and-planning — these diverse questions fit into a "system of activity" that is coherent, yet flexible. Similarly, previous 3Ps have defined 1B (in combination with 1A) as posing. But if, as suggested above, probing is defined to include the improvisational planning of probing activities (in 2B), then it makes sense, for consistency, to also define the preliminary planning of probing activities (in 1B) as probing, even though it occurs during the posing stage.

In this interpretation, posing asks questions, and probing tries to answer them. However, it can also be useful to define posing as "whatever scientists do while they are creating and planning a problem-solving project." Using this definition, posing includes 1A and 1B, plus 1C and maybe even 3C. Because a broad view of a project proposal can include preliminary decisions about WHAT to study (1A), HOW to study it (1B), WHY bother (1C), and WHEN the problem will be solved. For example, what are the evaluation criteria that will act as constraints on a solution (in 3C), that define an aiming point to guide the probing activities (planned in 1B, performed in 2B-and-2C) whose objective is to reach a level of confidence where a claim (in 3C) that "we have solved the problem" or "we have made significant progress toward a solution" seems justified. To increase our understanding of projects and posing, it would be helpful to have a longitudinal historical study of the what-how-why-when relationships (including both what was proposed and what was actually done) within individual projects — and across "families" of related projects — for research groups in various scientific disciplines and in design-oriented fields such as engineering. For example, one group might decide what to study (1A) and then how to study it (1B), while another group, after acquiring the equipment and expertise to excel in a particular probing technique (1B), might then ask "what can we study (1A) with our technique?"

Earlier, I recommended a four-way broadening of the definition of persuasion — to include all stages, self-persuasion, self-criticism, and pursuit. All of these ideas, even though they are not always called "persuasion" are already in 3Ps. Elizabeth Finkel (1993) describes the ongoing evaluation and self-persuasion (at the individual and group levels) that occurs within research groups, during all stages, when students solve GCK (Genetics Construction Kit) problems. Although I haven’t noticed, in 3Ps papers, any explicit exhortation to criticize one’s own arguments, there is plenty of emphasis on examining one’s own culturally biased assumptions and logic. John Jungck (1991, p. 161) warns about the use of "rhetorical power-moves on behalf of some authors" who try to imply that their own interpretations are objective, value-free, and uniquely correct. And "persuasion for pursuit" is certainly consistent with 3Ps philosophy.
My four suggestions about persuasion add little that is really new, but it may be useful to adopt an explicitly broader definition of persuasion, especially one that emphasizes the key role of critical evaluation in research. The backward-looking face of science (as described by Stewart & Jungck, 1993, p. 5) certainly includes the "logic associated with the acceptance of solutions" and "justification." But the logic of justification is also intimately linked with discovery and with the research process — in each of the 9 cells in Figure 1, justification-seeking evaluation is essential — so critical evaluation should be acknowledged as a key contributor to the creative, knowledge-constructing, forward-looking face of science.

This paper introduces one approach to exploring and extending 3Ps philosophy. A stages-and-activities approach — if it is not taken literally, but is viewed as a heuristic strategy for analysis and synthesis — has the potential to serve as a valuable tool for stimulating critical, creative thinking about scientific research and science education. As such, it may be an idea that is worthy of pursuit and continuing development.

References


Footnote
1 The definition used here is borrowed from Sue Johnson who, motivated by her experiences working in a research lab where problems were not always "solved" despite the intense activity invested in probing a problem situation, began to describe research activity as "problem probing that is done for the purpose of making progress toward solving a problem" This perspective, involves viewing the second P as problem probing rather than problem solving. This view has been received favorably by many people because 1) problem-oriented research does not always produce solutions; 2) probing implies an open-ended attitude that is less concerned with solving for "the correct answer" and is less afraid of making errors (according to Flannery, 1991, citing views expressed by John Jungck); and 3) "problem solving" has become a popular issue in science education and if we define it as "all 3Ps together" instead of just the middle P, this broadens the scope of problem solving and legitimates an increase in the attention focused on the two more frequently neglected Ps of posing and persuasion and on the advantages of "thinking opportunities" we make available to students. And experience widening is, after all, one of the main goals of BioQUEST. Also, the name change sounds linguistically better due to the alliteration.
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