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REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

AUSTRALIA: THE PBAC CURRICULUM—SCIENCE OR TECHNICAL TRAINING?

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ABSTRACT

For more than three decades, the Pharmaceutical Benefits Advisory Committee (PBAC) Guidelines have provided the dominant analytical framework for health technology assessment (HTA) in Australia, shaping university teaching, research centers, professional organizations and industry practice. This paper examines whether the resulting Australian HTA curriculum constitutes education in quantitative science or technical instruction in an inherited analytical methodology. The assessment is grounded in the principles of representational measurement, which require that measurement precede arithmetic, that multiplication and division be supported by lawful ratio measurement, that admissible arithmetic respect scale properties and dimensional homogeneity, and that quantitative claims be empirically evaluable, replicable and capable of falsification.

Drawing upon previous investigations of the Australian HTA knowledge base, the paper integrates evidence from measurement inversion, curriculum inversion and program-content inversion. Together these studies demonstrate a consistent pattern: representational measurement, ratio measurement, admissible arithmetic, the distinction between manifest and latent attributes, and Rasch measurement are absent from the organizing framework of Australian HTA, while utilities, quality-adjusted life-years (QALYs), incremental cost-effectiveness ratios (ICERs), reference-case simulation and related modelling techniques are comprehensively represented. The curriculum therefore begins with arithmetic and modelling rather than with the scientific principles required to determine whether those operations are quantitatively admissible.

The paper argues that the contemporary Australian HTA curriculum is epistemically closed. It assumes the scientific legitimacy of the PBAC analytical framework instead of teaching students how to determine whether that legitimacy exists. Once representational measurement is introduced, the analytical framework itself becomes the object of scientific evaluation. Utilities, QALYs, ICERs and simulation models must then satisfy the accepted requirements of lawful measurement before they can support quantitative claims. Because these requirements are not met, the PBAC analytical framework cannot be sustained as a scientifically valid quantitative framework. Universities may continue to teach it as technical instruction in an established administrative methodology, but they should no longer present it as education in quantitative science unless it is reconstructed upon the foundations of representational measurement.

INTRODUCTION

Health technology assessment (HTA) has, over more than three decades, become institutionalized throughout Australia. The analytical framework established by the Pharmaceutical Benefits Advisory Committee (PBAC) Guidelines has become the dominant reference point for university teaching, research centers, professional organizations and industry training [1]. Together these have established a closed epistemic framework through which successive generations of students are introduced to health economics, outcomes research, market access, comparative effectiveness research and health technology assessment. The curriculum has become remarkably uniform. Students learn utilities, quality-adjusted life-years (QALYs), incremental cost-effectiveness ratios (ICERs), decision analysis, reference-case simulation, uncertainty analysis and related modelling techniques as the accepted analytical methods of contemporary Australian HTA. These methods define the technical framework that students are expected to master.

Institutionalization, however, is not the same as scientific legitimacy. A methodology does not become science because it has been taught for forty years, incorporated into the PBAC Guidelines, endorsed by professional organizations or accepted by successive generations of practitioners. Scientific legitimacy depends upon a prior requirement: the methods being taught must satisfy the accepted standards governing quantitative measurement. That question has rarely been addressed because the contemporary Australian HTA curriculum is epistemically closed. Its organizing assumptions are treated as established knowledge rather than propositions open to scientific examination. Students are taught how to apply the framework, not how to determine whether its quantitative foundations are scientifically legitimate.

This epistemic closure explains why the curriculum has remained remarkably stable despite continual technical refinement. New statistical methods, increasingly sophisticated simulation models, Bayesian approaches, artificial intelligence, machine learning and computational advances have all been incorporated into contemporary HTA. Yet these developments occur entirely within the inherited analytical framework. They do not address the prior scientific question upon which the framework depends: do the quantities entering these analyses possess the measurement properties required to support the arithmetic performed? The curriculum therefore evolves technically while remaining epistemically closed to the body of scientific knowledge capable of evaluating its own quantitative foundations.

Previous investigations of the Australian HTA knowledge base consistently demonstrate the consequences of this closure. Measurement inversion, curriculum inversion and program-content inversion all reach the same conclusion [2] [3] [4] [5]. Representational measurement, measurement preceding arithmetic, ratio measurement, admissible arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes and Rasch measurement are absent from the organizing framework of contemporary Australian HTA. At the same time, utilities, QALYs, ICERs and reference-case simulation are comprehensively represented as though their quantitative legitimacy had already been established. The curriculum therefore reproduces measurement inversion while excluding the scientific principles capable of exposing it.

This paper asks a question that Australian universities can no longer avoid. Is the contemporary Australian HTA curriculum an education in quantitative science or technical instruction in an inherited analytical methodology? These are fundamentally different objectives. A scientific curriculum begins by teaching the principles that determine whether quantitative claims are possible. Technical instruction teaches students how to apply an accepted methodology. Once representational measurement becomes the organizing scientific principle, the distinction is decisive because the accepted methods of contemporary Australian HTA immediately become the object of scientific evaluation rather than unquestioned technical instruction.

The purpose of this paper is therefore not to ask whether the PBAC curriculum could be improved by adding another module or refining existing teaching. Epistemically closed systems cannot be reconstructed by tinkering around the edges. Representational measurement is not an additional topic within the curriculum; it is the scientific framework by which the curriculum itself is judged. If the central analytical constructs of the PBAC analytical framework fail that evaluation, the issue is no longer curriculum reform. It is whether Australian universities should continue to teach an inherited technical methodology as though it were a scientifically valid quantitative discipline.

1. WHAT SHOULD BE THE SCIENTIFIC FOUNDATION OF HEALTH TECHNOLOGY ASSESSMENT?

The defining responsibility of a university is to educate students in the principles of science rather than merely train them in technical methods. This distinction is particularly important in quantitative disciplines. Students should first understand the scientific principles governing measurement and quantitative inference before they are taught the analytical techniques that depend upon those principles. A curriculum that reverses this sequence may produce technically competent practitioners, but it cannot claim to have provided an education in normal quantitative science.

Health technology assessment is fundamentally a quantitative discipline because its purpose is to generate claims concerning therapy impact, comparative effectiveness and healthcare resource allocation. These claims are expected to influence clinical practice, reimbursement, formulary decisions and public policy. Universities therefore have a responsibility to ensure that students first understand the scientific conditions that determine whether such quantitative claims are possible. Those conditions are not matters of methodological preference. They are the accepted requirements of representational measurement.

Several principles are fundamental.

First, measurement must precede arithmetic. Numerical operations cannot create measurement where measurement does not already exist. Before arithmetic is undertaken, students should understand the attribute being measured, the properties of the measurement scale and the operations that the scale legitimately supports. This principle governs every quantitative discipline and provides the boundary between scientific measurement and the manipulation of numbers.

Second, attributes must be identified before they can be measured. Every quantitative claim concerns an attribute. Students should therefore learn to define precisely the characteristic whose change is to be assessed and determine whether it is manifest or latent. Without a clearly specified attribute there can be no meaningful measure and no scientifically interpretable claim concerning therapy impact.

Third, students must understand the hierarchy of measurement scales. Nominal, ordinal, interval and ratio scales are not alternative methods of assigning numbers but fundamentally different forms of measurement with different mathematical properties. Arithmetic is constrained by those properties. Multiplication, division and ratio formation require lawful ratio measurement. Numerical convenience cannot override these scientific constraints.

Fourth, representational measurement establishes the rules governing admissible arithmetic. Students should understand admissible transformations, dimensional homogeneity and the axioms that underpin meaningful quantitative measurement. These principles explain why numbers assigned to observations do not automatically become quantitative measures and why increasingly sophisticated statistical procedures cannot rescue quantities that fail the requirements of lawful measurement.

Fifth, manifest and latent attributes require different measurement strategies. Manifest attributes, such as survival time, hospital admissions, emergency department visits, treatment administrations or medication possession, may support linear ratio measurement where a defined unit and non-arbitrary zero exist. Latent attributes, including pain, fatigue, depression, physical functioning and need fulfilment, cannot be observed directly. Their measurement requires construction of an invariant quantitative continuum rather than the simple assignment or aggregation of numbers.

Sixth, students should understand that only two lawful ratio measures support claims of therapy impact. Manifest attributes require linear ratio measurement. Latent attributes require Rasch measurement, providing person-item conjoint measurement, invariant calibration and a logit ratio scale. These are not alternative methodological preferences but the only measurement frameworks that satisfy the requirements of representational measurement for their respective classes of attributes.

Finally, every quantitative claim should be formulated as an empirically evaluable and falsifiable proposition. HTA should generate claims that are credible, empirically evaluable, independently replicable and capable of falsification. Students should therefore learn how to formulate protocols specifying the attribute of interest, target population, comparator, measurement instrument, observation period and explicit criteria for success or failure. Claims that cannot subsequently be evaluated remain hypotheses rather than scientific evidence.

These principles define the scientific foundation of an HTA curriculum. They provide students with the scientific criteria required to evaluate the legitimacy of every subsequent quantitative method. Students no longer accept utilities, QALYs, incremental cost-effectiveness ratios or simulation models simply because they have become established technical standards. They first ask whether these constructs satisfy the requirements of lawful measurement and whether the arithmetic they support is scientifically admissible. Only after these foundations have been established should students be introduced to utilities, QALYs, cost-effectiveness analysis, decision modelling, budget impact analysis or other analytical techniques. The curriculum then proceeds in the correct scientific order: measurement determines arithmetic rather than arithmetic being assumed to create quantitative meaning.

This sequence provides the benchmark against which the contemporary Australian HTA curriculum, as institutionalized through the PBAC analytical framework, is assessed. The question is whether students are first provided with the scientific principles required to determine whether those methods satisfy the accepted standards of lawful measurement. If representational measurement is absent while the technical framework embodied in the PBAC Guidelines is comprehensively represented, the curriculum reverses the scientific order upon which quantitative disciplines are constructed. Students are taught how to perform arithmetic before they are taught how to determine whether that arithmetic is lawful. The curriculum therefore ceases to be an education in quantitative science and becomes technical instruction in an inherited analytical methodology organized around measurement inversion.

The seven principles outlined above establish the scientific foundations of quantitative health technology assessment. They also define the educational sequence that an HTA curriculum should follow. This requires a structured curriculum in representational measurement rather than the addition of an isolated measurement module to an existing HTA course.

To facilitate this transition, the author has developed a structured nine-unit transition program for faculty and students [6]. Beginning with the principle that measurement precedes arithmetic, the program progresses through the definition of attributes, scales of measurement, admissible arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement for manifest variables, Rasch measurement for latent variables, attribute possession, and finally the formulation of credible, empirically evaluable and falsifiable claims of therapy impact. Each unit builds logically upon the preceding one so that quantitative methods are introduced only after the measurement conditions necessary to support them have been established.

The purpose is not to append representational measurement to the existing HTA curriculum. It is to reverse the educational sequence that characterizes measurement inversion. Once measurement becomes the organizing scientific principle, the curriculum itself is reconstructed. Faculty and students learn first how to determine whether quantitative claims are scientifically possible and only then how to apply the analytical methods appropriate to those claims. The transition is therefore not from one HTA methodology to another, but from an epistemically closed technical framework to one grounded in the accepted principles of representational measurement and normal quantitative science.

2. IS THE CONTEMPORARY AUSTRALIAN HTA CURRICULUM: SCIENCE OR TECHNICAL TRAINING?

If the principles outlined in the previous section define the scientific foundations of a quantitative discipline, the question immediately becomes whether they characterize the contemporary Australian HTA curriculum. The evidence accumulated from successive interrogations of the Australian HTA knowledge base suggests that they do not. Rather than beginning with the scientific principles governing quantitative measurement, the curriculum begins with the technical methods embodied in the PBAC analytical framework. Students are introduced to a closed epistemic system covering health economics, economic evaluation, utilities, quality-adjusted life-years (QALYs), cost-effectiveness analysis, incremental cost-effectiveness ratios (ICERs), decision analysis, simulation modelling, uncertainty analysis and budget-impact modelling before they are taught the scientific principles required to determine whether these methods satisfy the requirements of lawful measurement. The scientific foundations that should determine whether these methods are quantitatively admissible are either absent or treated as epistemically irrelevant.

This conclusion is not based upon isolated examples or anecdotal observation. It emerges consistently from a series of investigations examining the publicly available Australian HTA knowledge base. Measurement inversion interrogations employing twenty-four canonical statements demonstrate systematic endorsement of propositions supporting utilities, QALYs, cost-effectiveness analysis and the PBAC reference-case analytical framework, while giving correspondingly weak endorsement to propositions that should define every quantitative science. Measurement preceding arithmetic, ratio measurement as the prerequisite for multiplication and division, admissible arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes, and Rasch measurement receive little or no explicit recognition.

The same pattern is reproduced educationally. Curriculum interrogations of Australian graduate teaching programs in health economics and outcomes research demonstrate curriculum inversion, where students are introduced to the analytical framework of contemporary HTA without first acquiring the scientific principles necessary to determine whether the arithmetic underlying that framework is admissible. Program-content assessments of Australian university research centers reach identical conclusions. Across these educational and research environments, representational measurement is consistently absent while the methods embodied in the PBAC analytical framework are comprehensively represented. The evidence points not to isolated institutional deficiencies but to a coherent national educational framework.

The consequence is the institutionalization of measurement inversion. Instead of asking whether utilities are lawful measures, students are taught how to estimate them. Instead of asking whether QALYs satisfy the requirements of ratio measurement, they are taught how to calculate them. Instead of asking whether an ICER is a scientifically meaningful ratio, they are taught how to interpret cost-effectiveness thresholds. Instead of asking whether the outputs of simulation models can be empirically evaluated and falsified, they are taught how to construct increasingly sophisticated models. Arithmetic becomes the starting point rather than the consequence of lawful measurement.

This distinction exposes the fundamental difference between education in science and technical training in an established analytical methodology. Scientific education equips students with the principles required to evaluate an analytical framework critically. Technical training equips students to apply that framework competently. The contemporary Australian HTA curriculum clearly succeeds in the latter objective. Graduates learn the techniques required by pharmaceutical manufacturers, consulting organizations, government agencies, university research centers and healthcare decision makers. They become proficient in preparing PBAC submissions, undertaking economic evaluations, interpreting QALYs, constructing simulation models and communicating value claims within the conventions of the PBAC analytical framework.

What they are not first taught is how to determine whether the analytical framework itself satisfies the accepted standards of representational measurement. The scientific legitimacy of the methodology is assumed rather than examined. The curriculum assumes the scientific legitimacy of the PBAC analytical framework instead of teaching students how to determine whether that legitimacy exists.

This omission is critical because representational measurement is not another analytical technique competing with cost-effectiveness analysis or decision modelling. It is the scientific framework that determines whether those methods are quantitatively admissible. Once students understand that measurement precedes arithmetic, that multiplication requires lawful ratio measurement, that arithmetic is constrained by scale properties, and that manifest and latent attributes require fundamentally different measurement strategies, the analytical framework of contemporary Australian HTA immediately becomes the object of scientific evaluation rather than unquestioning application.

The issue is therefore not whether the contemporary Australian curriculum produces graduates who can competently apply the methods of HTA. It clearly does. The issue is whether universities should regard competence in applying an inherited analytical framework as equivalent to education in quantitative science. The evidence presented here suggests that they cannot. A curriculum that teaches students how to construct utilities, QALYs, ICERs and simulation models before teaching them the scientific principles that determine whether those constructs are lawful measures is not educating scientists. It is providing technical instruction in an established analytical methodology organized around measurement inversion. Once representational measurement is introduced, the curriculum itself becomes the object of scientific evaluation. The question therefore changes fundamentally. It is no longer *How should students perform HTA?* It is *Should the PBAC analytical framework continue to be taught as quantitative science at all?* The answer to that question is considered in the final section.

3. SHOULD THE PBAC CURRICULUM BE TAUGHT AS SCIENCE?

The question posed by this paper is not whether the PBAC analytical framework has become an established technical discipline. It clearly has. Australian universities have developed sophisticated graduate programs, research centers have expanded rapidly, pharmaceutical manufacturers and consulting organizations recruit graduates with specialized HTA skills, and professional organizations have established an extensive educational infrastructure supporting the discipline. The issue is fundamentally different. Can Australian universities continue to present the PBAC analytical framework as a scientifically valid quantitative discipline once it is examined against the accepted standards of representational measurement?

The answer does not depend upon whether utilities, QALYs, cost-effectiveness analysis or simulation modelling have proved useful in supporting PBAC reimbursement decisions. Administrative usefulness does not establish scientific validity. Nor does widespread acceptance. Scientific disciplines are judged by the principles governing their methods, not by the number of practitioners who employ them. The central question is therefore whether the arithmetic underpinning the PBAC analytical framework satisfies the requirements of lawful measurement.

Previous investigations of the Australian HTA knowledge base provide a consistent answer. Measurement inversion demonstrates that the scientific propositions defining lawful measurement receive weak endorsement, while propositions supporting utilities, QALYs, cost-effectiveness analysis and the PBAC reference-case framework receive strong endorsement. Curriculum inversion demonstrates that students are introduced to these methods before learning the scientific principles required to evaluate them. Program-content inversion demonstrates that Australian universities and research centers comprehensively represent the methods embodied in the PBAC analytical framework while omitting representational measurement as the scientific foundation for quantitative analysis. These are not independent findings. They describe the same educational framework viewed from complementary perspectives.

The implications are profound. It is sometimes suggested that the problem could be resolved by introducing an additional module on representational measurement into existing HTA programs. This proposal misunderstands the role of measurement. Representational measurement is not another analytical technique that can simply be added to an already crowded curriculum. It is the scientific framework that determines whether every subsequent quantitative method is itself admissible. It therefore evaluates the curriculum rather than complements it.

Once students understand lawful measurement, the central constructs of the PBAC analytical framework immediately become objects of scientific scrutiny. They no longer ask how to estimate a utility score; they ask whether utilities are lawful measures. They no longer ask how to calculate a QALY; they ask whether multiplying an ordinal preference score by time satisfies the requirements of ratio measurement. They no longer ask how to construct an incremental cost-effectiveness ratio; they ask whether both numerator and denominator are lawful ratio measures capable of supporting ratio formation. They no longer judge simulation models by their technical sophistication alone; they ask whether the quantities entering those models possess the measurement properties required for the arithmetic performed and whether the resulting claims are empirically evaluable, replicable and falsifiable.

At that point, the relationship between representational measurement and the PBAC curriculum changes fundamentally. They cannot coexist as complementary components of a single scientific curriculum because they rest upon incompatible principles. Representational measurement requires that measurement govern arithmetic. The PBAC analytical framework assumes the legitimacy of arithmetic without first establishing that the quantities involved satisfy the requirements of lawful measurement. Once the scientific principles are understood, the PBAC framework is no longer accepted as the foundation of Australian HTA but becomes the subject of critical scientific evaluation.

This distinction exposes the difference between scientific education and technical training. Technical training prepares students to function effectively within an established analytical framework. Scientific education equips students to determine whether that framework itself satisfies the standards of quantitative science. The contemporary Australian HTA curriculum clearly achieves the first objective. It prepares graduates to construct economic evaluations, prepare PBAC submissions, develop cost-effectiveness models, undertake value assessments and participate successfully within the existing Australian HTA environment. What it does not do is provide students with the scientific principles necessary to determine whether those activities constitute lawful quantitative science.

Universities therefore face a choice that can no longer be avoided. They may continue to provide technical instruction in the existing PBAC analytical framework, or they may reconstruct HTA education around representational measurement, lawful ratio measurement and claims that are empirically evaluable, replicable and falsifiable. They cannot credibly combine these objectives within a single curriculum because representational measurement is not an additional topic within HTA. It is the scientific framework by which HTA itself is evaluated. Once that framework is introduced, the central constructs of the PBAC curriculum immediately become objects of scientific scrutiny rather than accepted analytical methods.

The issue is therefore no longer whether the PBAC analytical framework should be refined, updated or supplemented. Nor is it whether successive technical developments can rescue the existing analytical framework. The question is far more fundamental: should Australian universities continue to teach the PBAC curriculum as a scientifically valid quantitative discipline? If measurement precedes arithmetic, as representational measurement requires, then every quantitative construct taught within the PBAC curriculum must first demonstrate that it possesses the measurement properties necessary to support the arithmetic performed. Until that requirement is met, the PBAC analytical framework cannot claim the status of quantitative science. It remains an institutionalized technical methodology organized around measurement inversion. Universities may choose to teach that methodology as technical instruction, but they should no longer present it as education in quantitative science.

Universities therefore face a choice only in the narrow administrative sense. Scientifically, the outcome is already determined. Representational measurement is not another topic that can be added to the PBAC curriculum, nor can the existing curriculum be strengthened by incorporating a module on measurement theory. Representational measurement is the scientific framework by which the entire curriculum is judged. Once students understand that measurement precedes arithmetic, that multiplication, division and ratio formation require lawful ratio measures, and that admissible arithmetic is determined by scale properties, the central constructs of the PBAC analytical framework immediately become objects of scientific scrutiny. Utilities can no longer be assumed to be measures. QALYs can no longer be assumed to support multiplication. Incremental cost-effectiveness ratios can no longer be assumed to be meaningful quantitative ratios. Reference-case simulation can no longer be assumed to generate scientifically credible claims merely because increasingly sophisticated computational methods have been employed.

The consequence is unavoidable. The PBAC analytical framework survives only because it remains confined within an epistemic straitjacket that excludes the principles of representational measurement. Once that straitjacket is removed, the analytical framework collapses under its own internal contradictions. This is not a matter for continuing methodological debate because the governing scientific standards have long been established. The issue is therefore no longer whether Australian universities should continue to teach the PBAC curriculum as science. Once the requirements of lawful measurement are accepted, the answer follows directly. A curriculum whose central quantitative constructs fail the accepted standards of measurement can no longer be presented as education in quantitative science. It may continue as technical instruction in an historical administrative methodology, but it cannot legitimately retain its place as the scientific foundation of university education in health technology assessment.

CONCLUSION

This paper has not questioned whether the PBAC analytical framework has become an established analytical methodology. It clearly has. Over more than three decades it has existed as a closed epistemic technical framework comprising utilities, QALYs, incremental cost-effectiveness ratios, reference-case simulation, sensitivity analysis and associated modelling techniques. These methods have become standardized within Australian universities, research centers, government agencies, consulting organizations and the pharmaceutical industry. Students can therefore be trained to apply them competently and consistently.

That, however, is not the purpose of a university education in quantitative science.

A university has a higher obligation. It must first teach the scientific principles that determine whether quantitative claims are lawful before teaching the techniques that depend upon those claims. Students should first understand representational measurement, ratio measurement, admissible arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes and the requirement that scientific claims be empirically evaluable, replicable and falsifiable. Only then should they be introduced to quantitative analytical methods.

The evidence presented here demonstrates that the contemporary Australian HTA curriculum, organized around the PBAC analytical framework, reverses this scientific sequence. It teaches an established technical methodology before establishing whether that methodology satisfies the accepted standards of quantitative science. This is the defining characteristic of measurement inversion.

The consequence is unavoidable. Once students are educated in representational measurement, the central constructs of the PBAC analytical framework immediately become objects of scientific examination. They ask whether utilities are lawful measures, whether QALYs satisfy the requirements of ratio measurement, whether ICERs represent lawful ratios and whether simulation models generate claims capable of empirical evaluation and falsification. These are not peripheral questions. They determine whether the analytical framework itself possesses scientific legitimacy.

At that point, the curriculum cannot simply be revised or supplemented. Representational measurement is not an additional topic that enriches the PBAC analytical framework; it is the scientific standard by which that framework is judged. The two frameworks are therefore incompatible. One begins with lawful measurement and permits only admissible arithmetic. The other begins with arithmetic and assumes that measurement follows.

The choice facing Australian universities is therefore not between two alternative HTA curricula. Scientifically, there is no choice. Once representational measurement is accepted as the governing standard for quantitative claims, the analytical framework embodied in the PBAC curriculum becomes the object of scientific evaluation and collapses under its own internal contradictions. The issue is no longer whether the PBAC curriculum should be refined or supplemented. It is whether Australian universities should continue to teach an analytical framework whose central quantitative constructs fail the accepted standards of representational measurement.

Universities exist to educate students in quantitative science, not simply to train them in established technical methods. If the PBAC analytical framework is to retain its place within university education, it must first be reconstructed around the principles of representational measurement.

Otherwise, it should be recognized for what it is: an institutionalized technical methodology organized around measurement inversion rather than a scientifically valid quantitative discipline.

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