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# ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

# REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

# TEXAS: NORMAL SCIENCE AND THE ABSENCE OF REPRESENTATIONAL MEASUREMENT IN HTA EDUCATION

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## ABSTRACT

*Health technology assessment (HTA) depends upon quantitative claims concerning therapy impact, healthcare resource allocation and value for money. The scientific legitimacy of these claims rests upon a prior requirement: measurement must precede arithmetic. Representational measurement establishes the conditions under which numerical values may legitimately support arithmetic operations, while multiplication, division and ratio formation require lawful ratio measurement. These principles distinguish admissible quantitative science from numerical constructions that lack the measurement properties necessary to support meaningful arithmetic. The present study examines whether these foundational principles are explicitly represented within the publicly available Texas HTA and health-economics program-content knowledge base before the methods of contemporary HTA are introduced.*

*The assessment extends previous investigations of measurement inversion and curriculum inversion by evaluating statewide program content rather than estimating endorsement probabilities. Using a fixed 37-topic framework, seventeen topics represent the scientific requirements of representational measurement, including measurement preceding arithmetic, scales of measurement, ratio measurement, admissible arithmetic, dimensional homogeneity, manifest and latent attributes, linear ratio measurement and Rasch measurement. Twenty topics represent the contemporary HTA framework, including health economics, economic evaluation, utilities, quality-adjusted life-years (QALYs), cost-effectiveness analysis, patient-reported outcomes, decision analysis, simulation modelling and related analytical methods. The unit of analysis is the publicly available statewide program-content knowledge base expressed through university teaching, research programs, methodological statements and associated educational activities.*

*The assessment identifies a clear pattern of program-content inversion. None of the seventeen representational-measurement topics is explicitly represented within the publicly available Texas knowledge base, whereas all twenty contemporary HTA topics are comprehensively represented, producing a profile of 0/17 versus 20/20. Consequently, students and researchers are introduced to economic evaluation, utilities, QALYs, cost-effectiveness analysis, decision analysis and simulation modelling without first being provided with the scientific principles required to determine whether the arithmetic underpinning these methods is admissible. This finding is particularly significant because Texas possesses one of the largest and most technically sophisticated HTA, health-economics and outcomes-research environments in the United States. The issue is therefore not a lack of quantitative expertise but the absence of the measurement framework required to govern quantitative claims.*

*The findings demonstrate that the Texas HTA knowledge base is organized around the methods of contemporary HTA rather than the principles of representational measurement. Program-content inversion therefore institutionalizes arithmetic before measurement, perpetuating a framework in which utilities, QALYs and associated modelling methods are taught independently of the scientific requirements governing their admissibility. The paper concludes that representational measurement must become the organizing scientific principle of HTA, with lawful measurement*

*preceding arithmetic and quantitative claims restricted to those capable of empirical evaluation, replication and falsification in accordance with the standards of normal quantitative science*

## INTRODUCTION

Health technology assessment (HTA) depends upon quantitative claims. These claims are scientifically defensible only when measurement precedes arithmetic and the properties of the measurement scale permit the mathematical operations performed. Multiplication and division require ratio measurement; arithmetic must respect admissible transformations and dimensional homogeneity; and manifest and latent attributes require different approaches to measurement.

Previous interrogations of HTA knowledge bases in Australia, Canada, New Zealand and the United States have identified a consistent pattern of measurement inversion; endorsed by a companion study to this one for Texas [1]. The principles required for lawful measurement receive weak recognition, while utilities, QALYs, cost-effectiveness analysis and simulation modelling are strongly endorsed. Curriculum inversion reproduces the same failure educationally: students are introduced to the analytical methods of contemporary HTA without first being provided with the measurement principles required to determine whether the arithmetic underlying those methods is admissible.

The present investigation extends earlier research-center program-content assessments by examining the Texas HTA and health-economics program-content knowledge base as a whole. Texas provides an especially important setting because of the size, diversity and national influence of its academic health-sciences environment. Major programs and research activities associated with the University of Texas System, the Texas Center for Health Outcomes Research and Education (TxCORE), MD Anderson Cancer Center, Baylor College of Medicine, the University of Houston, Texas A&M University, UT Southwestern Medical Center and other university-affiliated programs encompass health economics, HTA, economic evaluation, outcomes research, health-services research, pharmacoeconomics, patient-reported outcomes, health policy and decision modelling. Texas therefore provides an unusually rich environment in which to examine the scientific foundations underlying contemporary quantitative health research.

The unit of analysis is not an individual university, research center or investigator. It is the publicly available program content through which the Texas HTA and health-economics knowledge base is expressed and reproduced. This includes teaching and training, program and course descriptions, research priorities, methodological statements, projects, publications, seminars and other publicly available descriptions of what relevant Texas programs research, apply and teach. The purpose is therefore to characterize the statewide program-content knowledge base rather than to infer what individual faculty members may know or address outside that publicly presented framework.

Two contrasting bodies of content are assessed using the fixed 37-topic framework. The first comprises 17 topics representing the requirements of representational measurement, including measurement preceding arithmetic, scales of measurement, admissible transformations, ratio measurement, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement and Rasch measurement [2 3]. The second comprises 20 topics representing contemporary health economics and HTA, including health economics, economic evaluation, utilities, QALYs, cost-effectiveness and cost-utility analysis, patient-reported outcomes, decision analysis, simulation and microsimulation, uncertainty analysis, value-of-information analysis, budget impact and related methods.

The question is deliberately narrow: does the Texas HTA and health-economics program-content knowledge base establish representational measurement as the foundation for quantitative claims before introducing or applying the arithmetic of contemporary HTA? If the requirements of representational measurement are absent while conventional HTA methods are extensively represented, the result is program-content inversion: an educational and research environment in which arithmetic and modelling proceed without first establishing that the quantities involved possess the measurement properties required to support the operations performed.

Texas provides a particularly demanding test of this question because it possesses one of the largest concentrations of HTA, pharmacoeconomics, outcomes research and health-services research expertise in the United States. The issue is therefore not whether Texas universities possess quantitative expertise. They clearly do. The question is whether representational measurement has been incorporated into the statewide HTA and health-economics program-content framework as the governing scientific standard for quantitative claims.

This distinction is fundamental. Representational measurement is not another methodology that can simply be added to contemporary HTA. It establishes the scientific rules governing the admissibility of arithmetic itself. Once those rules are applied, every numerical construct must satisfy them. The Texas review therefore assesses whether lawful measurement provides the scientific foundation for its HTA and health-economics program content or whether the legacy framework of contemporary HTA occupies that space without it. Given the scale, maturity and national influence of the Texas academic health-economics environment, the assessment provides an unusually demanding test of whether contemporary HTA program content is grounded in the measurement requirements of normal quantitative science.

## FOUNDATIONS OF QUANTITATIVE ANALYSIS

Before examining Texas program content, it is important to identify the scientific principles against which that content is assessed. These are not matters of methodological preference. They are the requirements of representational measurement that determine whether quantitative claims and the arithmetic operations supporting them are admissible.

Two principles are fundamental. First, measurement must precede arithmetic. Numerical operations cannot create measurement where measurement does not exist. Second, the arithmetic performed must be admissible for the measurement scale concerned. Operations involving multiplication, division and ratios require ratio measurement. For claims of therapy impact in HTA, this requires linear ratio measurement for manifest attributes or Rasch measurement for latent attributes.

These requirements establish the boundary between the manipulation of numbers and lawful quantitative measurement. Contemporary Texas HTA and health economics, by contrast, are organized around economic evaluation, utilities, QALYs, cost-effectiveness and cost-utility analysis, decision analysis and modelling. Over some forty years, these methods have become deeply embedded within Texas' extensive university and research environment, including the University of Texas System, Baylor College of Medicine, MD Anderson Cancer Center, the University of Houston, Texas A&M University, UT Southwestern Medical Center and other major academic institutions. Institutional acceptance, methodological sophistication and longevity, however, do not determine measurement status. The prior scientific question remains whether the quantities entering these analyses possess the measurement properties required for the arithmetic performed.

The Texas program-content review therefore asks a straightforward question: does the publicly available Texas HTA and health-economics knowledge base recognize representational measurement as the foundation for quantitative claims, or does it proceed directly to the methods and arithmetic of contemporary HTA without first establishing their measurement admissibility? This is the criterion governing the analysis that follows.

## MEASUREMENT BEFORE ARITHMETIC

Before students are introduced to health technology assessment, health economics, cost-effectiveness analysis or decision modelling, they should understand the scientific conditions that determine whether quantitative claims are possible. The governing principle is straightforward: measurement must precede arithmetic. Numbers cannot be manipulated legitimately merely because they have been assigned to observations. The properties of the measurement scale determine which arithmetic operations are admissible.

Representational measurement provides this foundation. The target attribute must first be identified and defined, its measurement properties established, and the appropriate scale constructed. Only then can arithmetic proceed. Multiplication and division require ratio measurement, admissible transformations must be respected, and dimensional homogeneity must be maintained. Reversing this sequence allows arithmetic to precede measurement and produces numerical constructions that cannot be interpreted as lawful quantitative measures.

For HTA claims of therapy impact, the distinction between manifest and latent attributes is fundamental. Manifest attributes are directly observable. Examples include survival time, hospital days, emergency department visits, treatment administrations and walking distance. Where a defined unit and non-arbitrary zero are established, these attributes support linear ratio measurement and the arithmetic permitted by a ratio scale.

Latent attributes, such as pain, fatigue, physical function or need fulfilment, cannot be observed directly. Assigning numbers to questionnaire responses or adding item scores does not establish measurement. A measurement model is required to construct a unidimensional continuum and demonstrate invariant measurement. For this purpose, Rasch measurement provides person-item conjoint measurement, specific objectivity and a logit continuum upon which possession of the latent attribute can be assessed.

The educational requirement can therefore be stated simply. Claims concerning manifest attributes require linear ratio measurement; claims concerning latent attributes require Rasch measurement.

Students should understand these requirements before being introduced to utilities, QALYs, cost-effectiveness ratios or simulation models. Numerical constructions do not acquire measurement properties merely through arithmetic, statistical analysis or incorporation into increasingly sophisticated models.

This sequence provides the criterion for assessing the Texas HTA and health-economics program-content knowledge base. The question is not how sophisticated its teaching, research, economic evaluation or modelling may be, nor how firmly established these methods have become across institutions such as the University of Texas System, Baylor College of Medicine, MD Anderson Cancer Center, the University of Houston, Texas A&M University, UT Southwestern Medical Center and other major academic programs. It is whether students and researchers are first provided with the measurement principles required to determine whether the arithmetic they subsequently perform is admissible. If representational measurement, ratio measurement and the distinction between manifest and latent attributes are absent while economic evaluation, utilities, QALYs and modelling are extensively represented, the result is program-content inversion. In Texas, the significance is heightened by the scale, diversity and national influence of its academic health-economics and HTA environment. The issue therefore concerns not a single course or institution, but the scientific foundations of one of the largest statewide HTA program-content knowledge bases in the United States.

## THE CRITICAL ROLE OF RATIO SCALES

The Texas program-content assessment rests upon a fundamental requirement of representational measurement: arithmetic operations are determined by the properties of the measurement scale. Numerical values cannot legitimately be multiplied, divided or otherwise manipulated merely because numbers have been assigned. Measurement must first be established and the proposed arithmetic must be admissible for the scale concerned.

The distinction between nominal, ordinal, interval and ratio scales is therefore critical. Nominal scales classify; ordinal scales establish order; interval scales provide equal intervals but lack a non-arbitrary zero. Only ratio scales possess both equal units and a non-arbitrary zero and therefore support meaningful ratios and the multiplicative arithmetic required for quantitative claims.

This requirement has immediate consequences for Texas HTA and health economics. QALYs multiply health-state values by time; incremental cost-effectiveness ratios divide differences in costs by differences in outcomes; and decision models combine probabilities, utilities, durations and other numerical inputs. These methods are extensively represented throughout Texas' academic health-economics and HTA environment. Where the quantities involved lack the measurement properties required for these operations, however, the arithmetic is inadmissible. Subsequent statistical analysis, modelling or simulation cannot correct that prior failure.

For claims of therapy impact, two forms of ratio measurement are relevant. Manifest attributes require linear ratio measurement. Latent attributes require Rasch measurement to construct an invariant quantitative continuum. This distinction provides the foundation for determining whether subsequent arithmetic is admissible.

The Texas assessment therefore applies a straightforward criterion. Does the publicly available statewide HTA and health-economics program-content knowledge base recognize ratio measurement, admissible arithmetic, dimensional homogeneity and the different measurement requirements of manifest and latent attributes before introducing the quantitative methods of contemporary HTA? Or does it proceed directly to economic evaluation, utilities, QALYs, cost-effectiveness analysis and modelling without first establishing the measurement properties required for their arithmetic?

Ratio measurement is therefore not simply another topic within an HTA curriculum or research program. It establishes the boundary between admissible quantitative analysis and the manipulation of numbers without the measurement properties required to support that analysis. For Texas, this criterion applies across one of the largest and most influential academic environments for health economics, pharmacoeconomics, outcomes research and health technology assessment in the United States. The issue is therefore not whether Texas possesses sophisticated quantitative expertise. It is whether that expertise is founded upon the measurement requirements necessary to support the quantitative claims being made.

## THE KNOWLEDGE BASE: PROGRAM CONTENT AND COVERAGE

The assessment uses the large language model interrogation framework applied in previous studies of measurement and curriculum inversion. The present analysis differs in one important respect: rather than estimating categorical probabilities of endorsement, it examines whether specified scientific and methodological topics are explicitly represented in the publicly available program content of the Texas HTA and health-economics knowledge base.

The Texas knowledge base comprises the publicly accessible teaching, research and training environment associated with universities and university-affiliated programs in health economics, health technology assessment, outcomes research, comparative effectiveness research, health services research, pharmacoeconomics, decision science and health policy. Material considered includes program descriptions, research priorities, methodological statements, projects, publications, seminars, training activities and related publicly available evidence. Relevant activities associated with the University of Texas System, the Texas Center for Health Outcomes Research and Education (TxCORE), MD Anderson Cancer Center, Baylor College of Medicine, the University of Houston, Texas A&M University, UT Southwestern Medical Center and other identifiable Texas programs contribute to this statewide knowledge base. The objective is not to evaluate individual investigators, courses or institutions, but to characterize the methodological framework represented across Texas as a whole.

As noted above, two contrasting groups of content are examined. The first represents representational measurement. It includes measurement preceding arithmetic, scales of measurement, the axioms of representational measurement, ratio measurement, admissible transformations and arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement for manifest attributes and Rasch measurement for latent attributes.

The second represents contemporary HTA. It includes health economics, economic evaluation, utilities and preference-based outcomes, QALYs, incremental cost-effectiveness ratios, decision analysis, decision trees, Markov models, simulation and microsimulation, probabilistic sensitivity analysis, value-of-information analysis and related modelling methods. Texas provides particularly extensive representation of these methods through its university programs, dedicated HTA and health-economics research centers, cancer centers, pharmaceutical and outcomes-research activities, comparative effectiveness research and health-policy programs.

The interrogation asks a single question: does the Texas HTA and health-economics program-content knowledge base establish representational measurement as the foundation for quantitative claims before presenting the analytical methods of contemporary HTA? The criterion is the presence or absence of explicit program content rather than a probability of endorsement.

This distinction is important. Earlier interrogations demonstrated the relative strength with which knowledge bases endorsed the propositions associated with measurement inversion and curriculum inversion. Program-content interrogation provides a more direct test. If representational measurement is absent while the methods of contemporary HTA are extensively represented, the result is program-content inversion. Arithmetic, modelling and simulation are taught, researched and applied without representational measurement being established as the prior framework determining whether those operations are admissible.

The Texas assessment therefore focuses on a narrow issue: whether the scientific requirements governing measurement are present in the statewide program-content knowledge base through which contemporary HTA and health economics are taught, researched and transmitted. The purpose is to determine whether lawful measurement provides the scientific foundation for quantitative analysis in Texas or whether the methods of the legacy HTA framework are represented without the prior measurement standards required to establish their arithmetic admissibility. Given the size, diversity and national influence of the Texas academic health-economics environment, the statewide knowledge base provides a particularly demanding test of that question.

## ASSESSMENT FRAMEWORK

For this assessment, the Texas program-content knowledge base was defined as the publicly available material describing relevant teaching and training in health economics, HTA, outcomes research, pharmacoeconomics and related fields. Sources included program and curriculum descriptions, courses and modules, syllabi where available, learning objectives, seminars, workshops, teaching resources and associated educational material. The purpose was to establish what students and trainees are expected to encounter across the Texas HTA and health-economics educational environment, not what individual faculty members may know or address in their independent research.

The relationship between the two components is the critical issue. Contemporary HTA methods cannot be taught independently of the measurement requirements governing their arithmetic. If students are taught that measurement precedes arithmetic, that multiplication and division require ratio measurement, and that manifest and latent attributes require different measurement strategies, they possess the scientific criteria required to judge whether subsequent HTA methods are admissible. Where these foundations are absent, utilities, QALYs, cost-effectiveness ratios and simulation models can be introduced without confronting the measurement properties required for their arithmetic.

Program-content inversion is therefore identified where contemporary HTA methods are comprehensively represented (20/20 topics) while the prior requirements of representational measurement are absent (0/17 topics). This is more than an imbalance in program content. It reverses the scientific sequence: arithmetic and modelling are introduced without first establishing the measurement conditions governing their admissibility.

Program-content inversion places contemporary Texas HTA in direct conflict with the standards of normal quantitative science. Scientific status does not follow from generating numbers, employing sophisticated statistical methods or constructing increasingly complex models. Quantitative science requires lawful measurement, admissible arithmetic, empirical evaluation, replication and the possibility of falsification. If the foundational requirements of representational measurement are absent while utilities, QALYs, ICERs and simulation models are represented without first establishing that their arithmetic is admissible, HTA is operating outside those requirements. The 0/17 versus 20/20 result therefore identifies more than an educational deficiency. It signals separation between the Texas HTA program-content framework and the measurement standards required by normal quantitative science.

This finding is particularly striking in Texas because the issue cannot plausibly be attributed to a lack of quantitative expertise or academic resources. Texas contains one of the largest and most sophisticated university-based environments for health economics, pharmacoeconomics, outcomes research, comparative effectiveness research and decision science in the United States. The program-content inversion identified here occurs within this highly developed academic environment. The problem is therefore not insufficient analytical sophistication, but the absence of the prior measurement framework required to determine whether that sophistication is being applied to quantities capable of supporting the arithmetic performed.

The two frameworks are consequently incompatible as foundations for quantitative analysis. Representational measurement requires arithmetic to be constrained by measurement. Once that principle is accepted, every subsequent quantitative method must satisfy its requirements. Numerical constructions cannot be exempted simply because they are established components of contemporary HTA, extensively taught across Texas, or supported by decades of methodological convention. Conversely, where representational measurement is absent from the organizing framework, there is no corresponding measurement constraint preventing such constructions from being taught, researched and applied. The Texas **0/17 versus 20/20** result captures this incompatibility in its starkest form.

## ASSESSMENT RESULTS PROGRAM CONTENT REVIEW

**Jurisdiction**
Texas, United States

**Knowledge Base**
Texas Health Technology Assessment Knowledge Base (Program Content)

**Purpose**

This review evaluates the publicly available program content associated with health technology assessment (HTA), health economics, pharmacoeconomics, outcomes research, comparative effectiveness research, health services research, pharmaceutical economics and related quantitative health research across Texas against the fixed 37-topic framework. The criterion is whether representational measurement is explicitly established as the scientific foundation for quantitative claims before the methods of contemporary HTA and health economics are taught, researched or applied.

The statewide knowledge base includes major activities associated with the University of Texas System, the Texas Center for Health Outcomes Research and Education (TxCORE), MD Anderson Cancer Center, Baylor College of Medicine, the University of Houston, Texas A&M University, UT Southwestern Medical Center and other identifiable university-affiliated programs with health-economics, pharmacoeconomics, outcomes-research and health-policy content. These programs explicitly identify economic evaluation, comparative effectiveness research, cost-effectiveness analysis, patient-reported outcomes, decision analysis, simulation modelling, real-world evidence, health-services research, value assessment and healthcare policy as central research and teaching activities. Texas therefore represents one of the largest and most technically sophisticated HTA and health-economics environments in the United States.

Topic results are presented in Table 1 for representational measurement.

## TABLE 1: REPRESENTATIONAL MEASUREMENT

| Topic | Explicitly recognized | Texas program evidence |
|---|---|---|
| Representational measurement | No evidence identified | — |
| Scales of measurement as constraints on arithmetic | No evidence identified | — |
| Measurement precedes arithmetic | No evidence identified | — |
| Axioms of representational measurement | No evidence identified | — |
| Ratio measurement as prerequisite for multiplication and division | No evidence identified | — |
| True zero and equal units | No evidence identified | — |
| Admissible transformations | No evidence identified | — |

| | | |
|---|---|---|
| Admissible arithmetic by scale type | No evidence identified | — |
| Dimensional homogeneity | No evidence identified | — |
| Manifest and latent attributes as distinct measurement classes | No evidence identified | — |
| Linear ratio measurement for manifest attributes | No evidence identified | — |
| Possession of latent attributes | No evidence identified | — |
| Rasch measurement as requirement for latent attributes | No evidence identified | — |
| Person-item conjoint measurement | No evidence identified | — |
| Specific objectivity and invariance | No evidence identified | — |
| Rasch logit ratio measurement for latent attributes | No evidence identified | — |
| Two admissible ratio measures for therapy impact | No evidence identified | — |

**Result: 0/17** representational-measurement topics explicitly recognized as the scientific foundation of the publicly available Texas HTA and health-economics program-content knowledge base reviewed.

The result is particularly noteworthy because Texas possesses one of the largest concentrations of HTA, health economics, outcomes research and pharmaceutical evaluation expertise in the United States. The review does not suggest an absence of quantitative sophistication. Rather, it demonstrates that the scientific framework governing lawful quantitative measurement is not explicitly represented within the publicly available educational and research material examined. Contemporary analytical methods are presented without first establishing the measurement principles that determine whether those methods are scientifically admissible.

Topic results for contemporary HTA are presented in Table 2.

## TABLE 2: CONTEMPORARY HEALTH ECONOMICS AND HTA FRAMEWORK

| Topic | Explicitly represented | Texas program evidence |
|---|---|---|
| Health economics | Yes | University of Texas System, University of Houston, Texas A&M and related programs |

| | | |
|---|---|---|
| Health technology assessment | Yes | TxCORE and university-affiliated HTA research activities |
| Economic evaluation | Yes | University of Texas, Baylor, University of Houston and associated research |
| Cost-effectiveness analysis | Yes | University of Texas programs, TxCORE, Baylor and MD Anderson |
| Cost-utility analysis | Yes | Economic-evaluation and value-assessment research across Texas programs |
| Pharmacoeconomics | Yes | University of Houston College of Pharmacy and pharmacy-related programs |
| Utilities and preference-based outcomes | Yes | Outcomes research, health-status assessment and economic evaluation |
| Quality-adjusted life-years (QALYs) | Yes | Cost-utility and outcomes-research activities statewide |
| Incremental cost-effectiveness ratios (ICERs) | Yes | Economic-evaluation and reimbursement research |
| Measurement and valuation of health outcomes / patient-reported outcomes | Yes | MD Anderson, Baylor, University of Texas and associated PRO research |
| Decision analysis | Yes | Decision-analysis and health-policy research programs |
| Decision-tree modelling | Yes | Health-economic modelling activities |
| Markov modelling | Yes | Economic evaluation and decision-modelling research |
| Simulation and microsimulation modelling | Yes | TxCORE, University of Texas and associated modelling programs |
| Probabilistic sensitivity and uncertainty analysis | Yes | Decision-modelling and economic-evaluation activities |
| Value-of-information analysis | Yes | Health-economic modelling research |
| Budget impact analysis | Yes | Health-policy and economic-evaluation programs |
| Health care priority setting and resource allocation | Yes | Health policy, value assessment and outcomes research |
| Value-for-money / value assessment | Yes | Comparative effectiveness and value-assessment research |
| Policy, reimbursement and decision use of economic evaluation | Yes | University of Texas System, Baylor, TxCORE and statewide health-policy research |

**Result: 20/20** contemporary health-economics and HTA topics represented in the publicly available Texas program-content knowledge base reviewed.

## TEXAS PROGRAM CONTENT ASSESSMENT

The Texas program-content assessment demonstrates a clear and internally consistent pattern of program-content inversion. Across the seventeen topics representing the scientific foundations of representational measurement, the review identified no explicit evidence that these concepts are established as the organizing framework for quantitative claims. In contrast, all twenty topics defining the contemporary health economics and HTA framework are explicitly represented throughout the publicly available program content. The resulting profile of 0/17 versus 20/20 is not simply an imbalance in emphasis. It represents a reversal of the scientific sequence upon which every quantitative discipline depends.

The significance of this finding lies in the relationship between the two groups of topics. The seventeen representational-measurement topics are not intended as an additional body of knowledge that may be taught alongside contemporary HTA. They are logically prior. They establish the scientific conditions that determine whether arithmetic is lawful before arithmetic is undertaken. Representational measurement defines the properties required of quantitative measures, the admissible arithmetic associated with different scales of measurement, the requirement for dimensional homogeneity, the distinction between manifest and latent attributes, and the lawful measurement systems appropriate for each. Only after these conditions have been satisfied can quantitative claims concerning therapy impact be regarded as scientifically meaningful.

The Texas program-content knowledge base does not establish this sequence. Publicly available descriptions of research programs, graduate teaching, methodological activities and professional training consistently emphasize health economics, economic evaluation, cost-effectiveness analysis, cost-utility analysis, pharmacoeconomics, patient-reported outcomes, decision analysis, simulation modelling, comparative effectiveness research and value assessment. What is absent is any explicit indication that these activities are governed by representational measurement or that measurement precedes arithmetic as the defining scientific principle.

This distinction is fundamental. Contemporary HTA depends upon multiplication, division, aggregation and ratio formation. Utilities are multiplied by survival time to generate QALYs. Incremental costs are divided by incremental QALYs to generate cost-effectiveness ratios. Preference scores are aggregated, transformed and incorporated into increasingly sophisticated decision models. These operations are scientifically permissible only if the quantities entering the arithmetic possess the measurement properties required for those operations. Yet the Texas program-content knowledge base introduces the analytical methods without first establishing the measurement requirements that determine whether those methods are admissible.

The 0/17 finding therefore identifies more than an omission from the educational environment. It demonstrates that representational measurement is not functioning as the scientific gatekeeper for quantitative analysis. Instead, the analytical framework begins with arithmetic and modelling, leaving the measurement status of the underlying quantities largely unexamined. This is the defining characteristic of program-content inversion.

Equally important is the 20/20 result. Every major component of the contemporary HTA framework is comprehensively represented within the Texas knowledge base. Health economics, pharmacoeconomics, economic evaluation, cost-effectiveness analysis, cost-utility analysis, utilities, QALYs, patient-reported outcomes, decision analysis, Markov modelling, simulation modelling, uncertainty analysis, value assessment and policy applications all occupy prominent positions within publicly available program descriptions. There is therefore no suggestion that Texas lacks technical sophistication or quantitative capability. On the contrary, the knowledge base reflects one of the largest and most mature HTA environments in the United States.

It is precisely this technical sophistication that makes the absence of representational measurement so significant. The issue is not whether Texas possesses expertise in statistics, economics or decision modelling. It clearly does. The issue is whether these analytical methods are explicitly governed by the scientific principles that determine whether the numbers entering those analyses are lawful measures. The review indicates that they are not.

This conclusion should not be interpreted as criticism of individual investigators or particular research projects. The assessment concerns the publicly available knowledge base as a whole rather than the views or expertise of individual faculty members. Program-content inversion describes the collective structure of the knowledge environment. It asks whether a student, researcher or practitioner engaging with the Texas HTA program content would encounter representational measurement as the organizing scientific principle before encountering the methods of contemporary HTA. The evidence indicates that they would not.

The implications extend beyond Texas. Public program content shapes the conceptual framework through which graduate students, early-career researchers and practitioners understand quantitative evaluation. When representational measurement is absent from that framework, successive generations are introduced directly to utilities, QALYs, economic evaluation and simulation modelling without first acquiring the scientific criteria necessary to judge whether those methods satisfy the requirements of lawful measurement. The program-content knowledge base therefore becomes the mechanism through which measurement inversion is reproduced.

The Texas findings closely parallel those reported previously for California, Australia, Canada, New Zealand and other HTA knowledge bases. Across these investigations, the same pattern emerges. Representational measurement is largely absent, while the methods of contemporary HTA are extensively represented. The consistency of these findings suggests that program-content inversion is not a characteristic of individual institutions but an institutional feature of the contemporary HTA paradigm itself.

The implications are therefore unavoidable. The Texas program-content knowledge base demonstrates that contemporary HTA is presented independently of the scientific framework that should govern its quantitative claims. Representational measurement, scales of measurement, admissible arithmetic, dimensional homogeneity, manifest and latent attributes, lawful ratio measurement and Rasch measurement are not explicitly established as the foundation upon which subsequent analytical methods depend. Until this relationship is reversed, publicly available program content will continue to present arithmetic before measurement, thereby perpetuating the international legacy of program-content inversion that characterizes contemporary health technology assessment.

## .CONCLUSION: THE CHALLENGE OF TRANSFORMATION

Now that the measurement problem has been exposed, the challenge facing Texas universities, research centers and the wider HTA and health-economics community is substantial. The issue is no longer whether contemporary HTA might benefit from greater attention to measurement theory. The Texas program-content findings, together with the accompanying evidence of measurement inversion, identify a foundational problem: the central analytical framework of contemporary HTA depends upon arithmetic operations that are inadmissible under the requirements of representational measurement and the standards of normal quantitative science. The measurement cat is now out of the contemporary HTA litter box. It cannot simply be put back.

There is therefore no scientific basis for defending the status quo. The relevant question is no longer whether utilities, QALYs and economic models have proved useful, gained widespread acceptance or been employed for decades in research and healthcare decision-making. Longevity and institutional acceptance do not establish quantitative validity. Once the requirements governing admissible arithmetic are applied, the problem becomes transparent. Multiplication requires ratio measurement. Arithmetic operations are constrained by scale properties. Dimensional homogeneity must be maintained. Numerical assignment cannot substitute for measurement. Where these requirements are violated, the resulting arithmetic is inadmissible. No degree of methodological refinement, statistical sophistication, simulation modelling or sensitivity analysis can alter that conclusion.

The challenge for Texas is therefore one of transformation: how should the Texas HTA knowledge base be reconstructed to satisfy the requirements of lawful measurement? Texas universities and research centers occupy a particularly influential position within American health economics, outcomes research, pharmacoeconomics and health-services research. Through graduate education, methodological research, professional training and collaborations with healthcare systems, government agencies and the pharmaceutical industry, they shape the analytical framework employed far beyond the state's borders. The 0/17 versus 20/20 program-content finding provides an opportunity to reconsider not simply the content of Texas HTA programs but the scientific sequence in which that content is presented. Measurement must become the foundation upon which subsequent quantitative methods are built rather than an omitted prerequisite.

The starting point is straightforward. Representational measurement must become the organizing scientific principle for HTA rather than an optional addition to existing programs. Students and researchers must first learn to define the target attribute, distinguish manifest from latent attributes, establish the appropriate form of lawful ratio measurement, determine which arithmetic operations are admissible for each scale type, and formulate claims capable of empirical evaluation, replication and falsification. Only after these requirements have been satisfied should economic evaluation, statistical modelling, simulation or other quantitative procedures be introduced.

This transformation does not abandon HTA. It places HTA within the accepted standards of normal quantitative science. Texas universities and research centers therefore face a clear choice: continue reproducing a legacy framework whose arithmetic fails the requirements of representational measurement or lead the reconstruction of HTA around lawful measurement. Given Texas' national prominence in health economics, pharmacoeconomics, outcomes research, comparative effectiveness research, decision science and healthcare policy, such a transformation would extend well beyond individual universities. The same standards governing measurement must apply whether quantitative claims originate in academic research, industry-sponsored studies, health-system evaluations, technology assessment or reimbursement decision-making.

Faculty necessarily have the leading educational role in this transition. This does not imply that investigators have knowingly disregarded representational measurement. Most faculty members were themselves educated within the contemporary HTA paradigm and continue to teach the methodological framework transmitted through universities, textbooks, journals, professional organizations and established research practice. The 0/17 finding demonstrates the extent to which representational measurement is absent from the publicly presented Texas program-content knowledge base. Transformation must therefore begin by providing faculty with the scientific knowledge and practical tools required to reconsider the foundations of what they teach and to reconstruct HTA education, research and methodological practice around lawful measurement, admissible arithmetic, evaluable claims and the standards of normal science.

It is precisely this gap that the Maimon Research nine-unit transformation program is intended to address [4]. The Maimon Research program is designed as more than a sequence of educational materials. It provides a structured template for faculty, researchers and practitioners seeking to understand and implement the transition from legacy HTA to a framework grounded in representational measurement. The program comprises 45,000 words of structured instructional material with the nine units moving progressively from measurement preceding arithmetic through attributes, scales of measurement, admissible arithmetic and dimensional homogeneity to the distinction between manifest and latent attributes, linear ratio measurement, Rasch measurement, attribute possession and the construction of empirically evaluable therapy-impact claims. The program can therefore be used for individual faculty preparation, as a framework for reconsidering existing graduate teaching, or as the foundation for developing a new postgraduate course in HTA organized around the requirements of lawful measurement and normal science.

An important feature of the program is that participants are not left simply to work through the material independently. Those enrolled have access to continuing 24/7 on line Q&A support as they study the units and, importantly, as they begin to apply the framework in teaching, research or therapy evaluation**.** Questions arising from particular attributes, proposed measures, Rasch applications, therapy-impact claims, protocols or curriculum development can be raised as they occur. The purpose is to support the transition from understanding the principles to applying them in practice. This continuing interaction is particularly important for faculty whose previous education did not include representational measurement and who may be reconsidering assumptions embedded in many years of teaching and research. The objective is not simply completion of nine units, but development of the capability to use the measurement framework independently and to introduce it confidently to students and colleagues.

The program can also provide a starting point for broader institutional engagement. Where universities, research centers, academic departments or professional groups wish to explore the implications of the new HTA in greater depth, additional activities can be developed around their particular requirements, including seminars, faculty discussions, workshops, small-group sessions, curriculum-development support and presentations addressing specific measurement or therapy-evaluation problems. These activities allow institutions to move beyond individual enrollment toward a wider reconsideration of how HTA is taught and applied. A fee is charged for access to the nine-unit program to support the maintenance, administration, updating and continuing availability of the system, including participant support. The larger objective, however, is transformation: to provide faculty and institutions with an accessible, supported pathway for replacing the legacy of measurement failure with graduate education grounded in lawful measurement, admissible arithmetic and empirically evaluable claims.

The nine-unit program is therefore offered as a template for faculty preparation and the development of a post-legacy graduate HTA program. Universities may use the framework to reconsider existing teaching or as the foundation for constructing a new graduate course organized explicitly around representational measurement.

Access to the program involves a fee. The purpose of that charge is to support the continuing maintenance of the system through which the program is provided, including hosting, administration, updating and continued availability of the educational materials. It should not obscure the larger purpose of the initiative. The objective is to make available a structured transition framework that universities and faculty can use to move beyond the measurement failures of contemporary HTA.

The required transformation therefore does not have to begin with each university independently reconstructing the measurement framework from first principles. The framework already exists. The immediate question is whether faculty and graduate programs are prepared to use it as the starting point for a post-legacy HTA curriculum grounded in lawful measurement, admissible arithmetic and the standards of normal science.

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