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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

NEW YORK: NORMAL SCIENCE AND THE ABSENCE OF REPRESENTATIONAL MEASUREMENT IN HTA EDUCATION

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ABSTRACT

Health technology assessment (HTA) presents itself as a quantitative discipline, yet the scientific legitimacy of its claims depends upon a requirement that precedes statistical analysis, economic evaluation and modelling: measurement must precede arithmetic. Representational measurement establishes that mathematical operations are constrained by scale properties, multiplication and division require ratio measurement, admissible transformations must be respected, and manifest and latent attributes require different measurement pathways. This study evaluates whether these principles provide the scientific foundation for the publicly represented HTA and health-economics program-content knowledge base of New York State.

*The assessment examines program content associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo***.** *A fixed 37-topic framework contrasts 17 topics defining representational measurement with 20 topics characterizing contemporary HTA and health economics. The unit of analysis is the collective publicly available program-content knowledge base rather than individual faculty knowledge or competence.*

The result is unequivocal: 0/17 representational-measurement topics were explicitly identified as foundations of quantitative analysis, while 20/20 contemporary HTA and health-economics topics were represented. This constitutes program-content inversion. Economic evaluation, utilities, QALYs, ICERs, patient-reported outcomes, decision analysis and modelling are extensively represented without an identifiable prior framework establishing whether the numerical quantities involved possess the measurement properties required for the arithmetic performed.

The significance of the finding is heightened by the academic standing and quantitative sophistication of the institutions examined. The problem cannot plausibly be attributed to inadequate analytical expertise. Rather, the findings indicate that a highly developed quantitative superstructure has emerged without an explicit representational-measurement foundation.

The implication for graduate education is fundamental. Adding measurement as another topic to the legacy curriculum is insufficient. Representational measurement must become its organizing scientific principle. Therapy-impact claims should begin with attribute definition and proceed through linear ratio measurement for manifest attributes or Rasch logit ratio measurement for latent attributes before arithmetic is undertaken. The New York 0/17 versus 20/20 result therefore identifies not a minor curricular omission but a reversal of the required scientific sequence. Reconstruction requires moving from arithmetic before measurement to measurement before arithmetic, providing students with the foundations necessary to construct empirically evaluable, replicable and falsifiable quantitative claims.

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. The principles required for lawful measurement receive weak or no identifiable recognition, while utilities, QALYs, cost-effectiveness analysis and simulation modelling are strongly represented. 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 New York State HTA and health-economics program-content knowledge base as a whole. New York provides an especially important setting because of the scale, standing and diversity of its university-based medical and health-research environment. The knowledge base examined encompasses major activities associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo. Collectively, these environments encompass health economics, economic evaluation, comparative effectiveness research, outcomes research, health services research, patient-reported outcomes, health policy, decision science and quantitative healthcare research. New York therefore provides a substantial test of 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 New York 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 New York 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, believe 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. 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 New York 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.

New York makes this question particularly consequential. The institutions examined are not peripheral participants in American quantitative health research. They are major universities, medical schools and public-health environments with substantial influence through graduate education, research, publication, professional training and the subsequent careers of their students. Their program content contributes not merely to what is researched today but to the intellectual framework transmitted to future investigators, faculty and practitioners. If representational measurement is absent from that framework, the omission can be reproduced across successive generations regardless of the sophistication of the analytical techniques being taught.

This is particularly striking given New York's broader place in the history of quantitative scholarship. The issue cannot reasonably be attributed to an absence of access to the scientific literature of measurement. The formal requirements governing scales of measurement, admissible transformations and quantitative representation have been available for decades . The question is whether those requirements penetrated the epistemic framework of HTA and health economics. The present interrogation asks whether they can be identified as governing principles within the publicly represented New York program-content knowledge base.

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. Utilities, QALYs, ICERs, patient-reported outcome scores and modelled claims do not acquire quantitative legitimacy because they are familiar, extensively published or institutionally endorsed. Their legitimacy depends upon whether the underlying attributes have been defined, the required measurement properties established and the arithmetic shown to be admissible.

The New York review therefore asks a question that precedes methodological sophistication: **is** the arithmetic lawful? The breadth and standing of the New York academic environment make this an especially demanding test. If a knowledge base of this sophistication comprehensively represents the methods of contemporary HTA while failing to represent the measurement standards required to justify them, the problem cannot readily be dismissed as a local curricular omission. It points instead to the institutional reproduction of a much deeper epistemic failure within contemporary HTA. The purpose of the present review is to determine whether that is what the New York program-content knowledge base reveals.

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FOUNDATIONS OF QUANTITATIVE ANALYSIS

Before examining New York 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 logit ratio measurement for latent attributes.

These requirements establish the boundary between the manipulation of numbers and lawful quantitative measurement. Contemporary New York HTA and health economics, by contrast, are organized around economic evaluation, utilities, QALYs, cost-effectiveness and cost-utility analysis, decision analysis, outcomes research and modelling. Over some forty years, these methods have become deeply embedded within New York's university and research environment, including major programs associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo. These institutions represent a substantial concentration of expertise in health economics, comparative effectiveness research, outcomes research, health services research, decision science and healthcare policy.

That sophistication does not resolve the measurement question. Institutional acceptance, methodological complexity, extensive publication and longevity do not determine measurement status**.** A numerical construct does not become a measure because it has been used for decades, incorporated into economic models or accepted within a professional discipline. The prior scientific question remains whether the attribute has been defined, whether its measurement properties have been established and whether those properties support the arithmetic subsequently performed.

This distinction is particularly important for utilities, QALYs and cost-effectiveness analysis. Before a health-state value can legitimately be multiplied by time, the measurement properties required for that multiplication must first be demonstrated. Before a ratio such as cost per QALY can be interpreted quantitatively, the denominator must possess the measurement properties required to support the operations from which it is constructed. Modelling cannot repair a failure of measurement at the level of its inputs**.** If the required measurement properties have not been established, additional mathematical sophistication merely operates upon quantities whose quantitative status remains unresolved.

The same principle applies to therapy-impact claims involving patient-reported outcomes and other latent attributes. Assigning numbers to responses does not itself create measurement. The attribute must be defined as unidimensional and a measurement continuum constructed that satisfies the required properties. Within the framework applied here, this requires Rasch person-item conjoint measurement and the construction of a Rasch logit ratio measure capable of supporting defensible claims concerning possession and change in the latent attribute.

The New York program-content review therefore asks a straightforward but fundamental question: does the publicly available New York 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 logit ratio 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 New York's 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 major academic environments associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo. These institutions collectively represent a formidable concentration of expertise in medicine, public health, health economics, outcomes research, comparative effectiveness research, decision science and health-services research. That analytical sophistication, however, does not itself establish that the quantities being analyzed satisfy the requirements of measurement.

The prior question 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, admissible transformations, dimensional homogeneity and the distinction between manifest and latent attributes are absent while economic evaluation, utilities, QALYs, ICERs and modelling are extensively represented, the result is program-content **inversion.** The methods requiring quantitative justification have been placed before the scientific framework required to provide that justification.

In New York, the significance therefore lies not simply in the findings for individual universities or research environments but in the consistency with which the same analytical framework is reproduced across some of the state's most prominent academic health institutions. A 0/17 representational-measurement result alongside 20/20 representation of contemporary HTA cannot reasonably be treated as the accidental omission of a few specialist topics. It points to a much deeper reversal of the required scientific sequence.

The issue therefore concerns not a single course, department or institution, but the scientific foundations of New York's HTA and health-economics program-content knowledge base. If graduate education is intended to prepare students for the quantitative assessment of therapy impact, the first responsibility is not to teach them how to manipulate the established numerical constructs of HTA. It is to give them the scientific knowledge required to determine whether those constructs are measures and whether the arithmetic they are being asked to perform is lawful. Only after that foundation has been established should the analytical methods of HTA follow.

THE CRITICAL ROLE OF RATIO SCALES

The New York 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 New York 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 across New York's academic health-economics and HTA environment, including activities associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo. Where the quantities involved lack the measurement properties required for these operations, however, the arithmetic is inadmissible. Subsequent statistical analysis, modelling, simulation or sensitivity analysis cannot correct a measurement failure that occurred before those procedures began.

For claims of therapy impact, two forms of ratio measurement are relevant. Manifest attributes require linear ratio measurement. Latent attributes require Rasch logit ratio measurement to construct an invariant quantitative continuum upon which possession of the attribute can be assessed. This distinction provides the foundation for determining whether subsequent arithmetic is admissible. It also means that defining the attribute is logically prior to selecting the analytical method. One cannot decide what arithmetic to perform until one knows what is being measured and what measurement properties have been established.

The New York 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, ICERs, cost-effectiveness analysis and modelling without first establishing the measurement properties required for their arithmetic?

The 0/17 versus 20/20 result makes this question particularly important. The issue is not simply that ratio measurement receives insufficient attention. None of the 17 topics defining the representational-measurement foundation was explicitly identified, while all 20 topics defining the contemporary HTA and health-economics framework were represented. The program-content knowledge base therefore displays the methods requiring arithmetic without displaying the measurement framework required to establish whether that arithmetic is lawful. This is the essence of program-content inversion.

Ratio measurement is consequently not simply another topic that might usefully be added to 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**.** A university cannot solve the problem by inserting a lecture on scales of measurement while continuing to teach utilities, QALYs, ICERs and modelling as though nothing has changed. Once students understand that multiplication and division require ratio properties, that knowledge must govern the quantitative methods subsequently taught.

For New York, this criterion applies across an exceptionally prominent academic environment encompassing medical schools, schools of public health, health-economics programs, comparative-effectiveness research, outcomes research, decision science, health-services research and healthcare policy. The issue is therefore emphatically not whether New York possesses sophisticated quantitative expertise. It clearly does. The issue is whether that expertise is founded upon the measurement requirements necessary to support the quantitative claims being made. The 0/17 versus 20/20 finding indicates that, in the publicly represented program-content knowledge base reviewed, that foundation is absent.

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 New York HTA and health-economics knowledge base.

The New York 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 Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo contribute to the statewide knowledge base examined here. The objective is not to evaluate individual investigators, courses or institutions, but to characterize the methodological framework represented across these major New York academic environments 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 as constraints on arithmetic, the axioms of representational measurement, ratio measurement, true zero and equal units, admissible transformations, admissible arithmetic, dimensional homogeneity, the distinction between manifest and latent attributes, linear ratio measurement for manifest attributes, possession of latent attributes, person-item conjoint measurement, specific objectivity and invariance, and Rasch logit ratio measurement for latent attributes. Together these topics establish the scientific conditions that must be satisfied before numerical operations can support defensible quantitative claims.

The second represents contemporary HTA and health economics. It includes health economics, HTA, economic evaluation, cost-effectiveness and cost-utility analysis, pharmacoeconomics, utilities and preference-based outcomes, QALYs, incremental cost-effectiveness ratios, patient-reported outcomes, decision analysis, decision trees, Markov models, simulation and microsimulation, probabilistic sensitivity analysis, value-of-information analysis, budget impact, priority setting, value assessment and the policy and reimbursement use of economic evaluation. New York provides extensive representation of these methods through its medical schools, schools of public health, health-economics and outcomes-research programs, comparative-effectiveness and decision-science activities, health-services research and healthcare-policy environments.

The interrogation asks a single question: does the New York 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 an estimated probability of endorsement.

This distinction is important. Earlier interrogations demonstrated the relative strength with which knowledge bases endorsed propositions associated with measurement inversion and curriculum inversion. Program-content interrogation provides a more direct test. It asks what the publicly represented academic knowledge base actually contains. If representational measurement is absent while the methods of contemporary HTA are comprehensively represented, the result is program-content inversion. Arithmetic, modelling and simulation occupy the methodological foreground without representational measurement being established as the prior scientific framework determining whether those operations are admissible.

The 0/17 versus 20/20 comparison provides an especially stark expression of that inversion. It does not claim that no individual New York faculty member has encountered measurement theory or that no isolated course, publication or research project contains measurement-related material. The criterion is more demanding and more relevant to graduate education: whether representational measurement is explicitly incorporated into the publicly identifiable program-content knowledge base as the scientific foundation governing quantitative analysis. An isolated reference to measurement, psychometrics, validity, reliability or item response theory would not satisfy that criterion if it does not establish the relationship between measurement properties and admissible arithmetic.

This is crucial because the two sides of the interrogation are not equivalent collections of optional methodological topics. The 20 contemporary HTA topics describe methods that operate upon numbers. The 17 representational-measurement topics establish whether those numbers possess the properties required for those operations. **The measurement framework is logically prior.** Cost-effectiveness analysis, QALYs, ICERs and simulation modelling cannot establish their own quantitative legitimacy. That legitimacy depends upon the measurement status of the quantities entering them.

The New York assessment therefore focuses on a narrow but fundamental 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 New York or whether the methods of the legacy HTA framework are represented without the prior measurement standards required to establish their arithmetic admissibility.

Given the standing and methodological sophistication of Weill Cornell, NYU, Columbia, Mount Sinai, Rochester and Buffalo, this provides a particularly demanding test. If representational measurement is not identifiable as an organizing scientific foundation across such a substantial academic environment while the full contemporary HTA framework is readily identifiable, the finding cannot readily be dismissed as a shortage of quantitative expertise. It points instead to a deeper question concerning what New York's HTA and health-economics knowledge base recognizes as the foundations of quantitative science and what it consequently transmits to the next generation of students and researchers.

ASSESSMENT FRAMEWORK

For this assessment, the New York program-content knowledge base was defined as the publicly available material describing relevant teaching and training in health economics, HTA, outcomes research, comparative effectiveness research, pharmacoeconomics, decision science 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 knowledge base encompasses major activities associated with Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo. The purpose was to establish what students and trainees are expected to encounter across this New York 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 of the assessment is the critical issue. Contemporary HTA methods cannot be separated from the measurement requirements governing their arithmetic. If students are taught that measurement precedes arithmetic, that multiplication and division require ratio measurement, that admissible operations are determined by scale properties, 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 required scientific sequence. The methods requiring arithmetic are taught and researched before the measurement conditions governing the admissibility of that arithmetic have been established**.** Students can therefore become proficient in manipulating numbers without first being equipped to determine whether those numbers constitute measures capable of supporting the operations performed upon them.

Program-content inversion places contemporary New York HTA in direct conflict with the standards expected of normal quantitative science. Scientific status does not follow from generating numbers, employing sophisticated statistical techniques, publishing extensively or constructing increasingly elaborate 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, the quantitative framework has failed at a point logically prior to modelling. No subsequent statistical or computational sophistication can repair that failure. The 0/17 versus 20/20 result therefore identifies more than an educational deficiency. It signals a separation between the New York HTA program-content framework and the measurement standards required for defensible quantitative claims.

This finding is particularly significant in New York because it cannot plausibly be attributed to a lack of quantitative expertise, institutional resources or academic standing. The institutions examined represent a formidable academic environment encompassing medical schools, public-health programs, health economics, comparative effectiveness research, outcomes research, decision science, health-services research and healthcare policy. The 20/20 result confirms the sophistication of that environment. The problem is therefore almost the reverse: an extensive quantitative superstructure has been developed without an identifiable representational-measurement foundation establishing what arithmetic its numerical inputs are entitled to support.

That distinction makes the New York result particularly difficult to dismiss. The issue is not whether these institutions teach quantitative methods. They clearly do. Nor is it whether faculty are accomplished researchers within their respective fields. The interrogation does not assess individual competence. The issue is whether the program-content framework itself establishes the measurement rules by which its quantitative methods can be judged. On the fixed framework applied here, it does not. The knowledge base comprehensively represents what contemporary HTA does with numbers while failing to represent the prior scientific requirements that determine what may legitimately be done with those numbers.

The two frameworks are consequently incompatible as organizing 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. Utilities cannot be assumed to support multiplication because HTA convention requires QALYs. QALYs cannot be presumed to be measures because they have been used for decades. ICERs cannot acquire quantitative legitimacy merely because cost-effectiveness analysis is institutionally established. Simulation cannot transform inadmissible inputs into admissible measures. Measurement properties cannot be created retrospectively by arithmetic.

Conversely, where representational measurement is absent from the organizing framework, there is no prior measurement constraint preventing these numerical constructions from being taught, researched and applied. That is precisely what makes program-content inversion consequential. It allows the conventions of the discipline to determine what arithmetic is performed rather than requiring the properties of measurement to determine what arithmetic is permitted.

For graduate education, the implications are unavoidable. A student introduced to utilities, QALYs, ICERs and modelling without first being taught ratio measurement, admissible transformations, dimensional homogeneity and the distinction between manifest and latent measurement is not being given the knowledge required to evaluate the scientific legitimacy of the methods being taught. The student is being trained within the legacy framework rather than being educated to assess it critically. A university program in quantitative therapy evaluation should do more than reproduce the prevailing practices of a profession; it should provide students with the scientific standards necessary to determine whether those practices survive quantitative scrutiny.

The New York 0/17 versus 20/20 result captures this incompatibility in its clearest form. On one side is a comprehensive legacy HTA framework built around economic evaluation, utilities, QALYs, ICERs, decision analysis and modelling. On the other is the representational-measurement framework required to determine whether those operations are scientifically admissible—and none of its 17 foundational topics is explicitly represented. This is not simply missing content. It is a reversal of the scientific order upon which quantitative analysis depends: arithmetic before measurement rather than measurement before arithmetic.

ASSESSMENT RESULTS PROGRAM CONTENT REVIEW

New York, United States

Knowledge Base

New York Health Technology Assessment, Health Economics and Outcomes Research Program-Content Knowledge Base

Purpose

This review evaluates publicly available program content associated with health technology assessment (HTA), health economics, economic evaluation, outcomes research, health services research, pharmaceutical economics and related quantitative health research in New York State 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 reviewed here includes major activities associated with Weill Cornell Medicine; NYU Grossman School of Medicine; Columbia University Mailman School of Public Health; the Icahn School of Medicine at Mount Sinai; the University of Rochester Medical Center; and the University at Buffalo, together with their associated departments, divisions and research programs. Publicly available program descriptions identify substantial activity in health economics, comparative effectiveness research, outcomes research, economic evaluation, decision science, cost-effectiveness analysis, health services research, health policy, patient outcomes and related quantitative methods. For example, Weill Cornell identifies comparative effectiveness, outcomes research, cost-effectiveness and health policy/economics as major activities, while Columbia's Comparative Effectiveness and Outcomes Research program explicitly includes decision analysis and cost-effectiveness analysis. These programs collectively constitute the New York HTA and health-economics program-content knowledge base evaluated here.

Topic results are presented in Table 1 for representational measurement.

TABLE 1: REPRESENTATIONAL MEASUREMENT

Topic	Explicitly recognized	New York 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	—

Topic	Explicitly recognized	New York program evidence
Two admissible ratio measures for therapy impact	No evidence identified	—

Result: 0/17 representational-measurement topics explicitly recognized as foundations of the publicly available New York HTA/health economics program-content knowledge base reviewed.

The New York result is particularly striking because the institutions reviewed represent some of the most prominent medical, public-health and health-research environments in the United States. The finding cannot readily be attributed to an absence of quantitative expertise. The opposite is the case. The New York knowledge base demonstrates extensive sophistication in health economics, comparative effectiveness research, outcomes research, statistics, epidemiology, decision analysis and economic evaluation. What is not identified is the prior representational-measurement framework required to determine the quantitative status of the numbers entering those analyses. The organizing principles of lawful measurement are therefore absent from the publicly represented New York program-content knowledge base reviewed.

Topic results for contemporary HTA are presented in Table 2.

TABLE 2: CONTEMPORARY HEALTH ECONOMICS AND HTA FRAMEWORK

Topic	Explicitly represented	New York program evidence
Health economics	Yes	Weill Cornell, NYU, Columbia, Mount Sinai, Rochester and Buffalo environments
Health technology assessment	Yes	HTA, comparative-effectiveness and healthcare decision-research activities
Economic evaluation	Yes	Health-economics, outcomes and policy programs
Cost-effectiveness analysis	Yes	Weill Cornell, Columbia, Mount Sinai and other New York research activities
Cost-utility analysis	Yes	Economic-evaluation and health-outcomes research
Pharmacoeconomics	Yes	Pharmacy, pharmaceutical and outcomes-research environments
Utilities and preference-based outcomes	Yes	Health-outcomes and economic-evaluation research
Quality-adjusted life-years (QALYs)	Yes	Cost-effectiveness and value-assessment research

Topic	Explicitly represented	New York program evidence
Incremental cost-effectiveness ratios (ICERs)	Yes	Economic-evaluation and cost-effectiveness research
Measurement and valuation of health outcomes / patient-reported outcomes	Yes	Outcomes and comparative-effectiveness research
Decision analysis	Yes	Columbia CEOR and other decision-science programs
Decision-tree modelling	Yes	Decision-analysis and economic-evaluation activities
Markov modelling	Yes	Health-economic modelling and economic-evaluation research
Simulation and microsimulation modelling	Yes	Decision-science and comparative-effectiveness research
Probabilistic sensitivity and uncertainty analysis	Yes	Economic-evaluation and modelling activities
Value-of-information analysis	Yes	Decision-science and health-economic modelling
Budget impact analysis	Yes	Health-economics and healthcare-policy environments
Health care priority setting and resource allocation	Yes	Health-policy, economics and CEOR programs
Value-for-money / value assessment	Yes	Health-economics, cost-effectiveness and outcomes research
Policy, reimbursement and decision use of economic evaluation	Yes	Health-policy and health-economics research

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

The strength of this second result is illustrated by the program descriptions themselves. Weill Cornell reports research in comparative effectiveness and cost-effectiveness and maintains a Division of Health Policy and Economics. Columbia's Comparative Effectiveness and Outcomes Research program trains students to compare effectiveness, risks and costs and explicitly includes decision analysis, cost-effectiveness analysis, HTA and resource allocation. Mount Sinai-associated research has employed lifetime cost-effectiveness analysis expressed in costs and QALYs, while University at Buffalo activities explicitly recognize pharmacoeconomics and cost-effectiveness.

ASSESSMENT OF THE NEW YORK RESULT

The New York program-content review identifies a complete inversion in the scientific ordering of health technology assessment education and research. Across the fixed 37 topics examined, none of the 17 topics defining representational measurement is explicitly recognized as the scientific foundation for quantitative claims, while all 20 topics associated with contemporary health economics and HTA are represented. The resulting profile of 0/17 for representational measurement and 20/20 for the contemporary HTA framework is not a minor curriculum imbalance. It indicates that the methods of contemporary HTA are taught, researched and applied without prior establishment of the measurement conditions required to support their arithmetic.

The significance of this result is magnified by the institutions involved. Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo represent some of the strongest academic environments in the United States for medicine, public health, health economics, outcomes research, comparative effectiveness research, decision science and health-services research. The 20/20 result demonstrates the breadth and sophistication of the analytical knowledge base. The problem is therefore not lack of expertise. It is that this expertise has developed without an identifiable representational-measurement framework governing what the numbers entering those analyses are entitled to mean and what arithmetic they are entitled to support.

This distinction is decisive. A field does not become quantitatively scientific because it uses advanced statistics, complex models, large datasets or sophisticated software. The prior question is whether the quantities being analyzed are measures and whether the operations performed upon them are admissible. That question is logically prior to every subsequent stage of analysis. If the measurement status of the inputs has not been established, additional modelling does not correct the problem. It merely compounds it.

The New York result therefore exposes something more serious than omitted curriculum content. It identifies a knowledge base in which arithmetic has effectively been allowed to precede measurement. Economic evaluation, cost-effectiveness analysis, utilities, QALYs, ICERs, decision analysis and simulation modelling are extensively represented, while ratio measurement, admissible transformations, dimensional homogeneity and the measurement constraints governing multiplication and division are absent from the publicly represented foundation. The sequence is reversed. Methods that require quantitative justification appear before the scientific standards necessary to determine whether that justification exists.

The implications for utilities and QALYs are immediate. If health-state values do not satisfy the requirements of ratio measurement, multiplication by time cannot be justified merely because the operation is mathematically convenient or institutionally established. The resulting QALY does not acquire lawful measurement properties through arithmetic. The same problem then propagates into the incremental cost-effectiveness ratio. If the effectiveness denominator does not constitute a defensible ratio measure, the cost-per-QALY calculation cannot be rescued by more sophisticated modelling, probabilistic sensitivity analysis or simulation. The 0/17 versus 20/20 finding therefore points directly to a structural problem in the contemporary HTA framework rather than a peripheral deficiency.

The same issue applies to patient-reported outcomes. The New York knowledge base contains substantial activity in outcomes research and health-status assessment, yet the program-content interrogation does not identify the distinction between manifest and latent attributes as an organizing measurement principle. Nor does it identify person-item conjoint measurement, specific objectivity, invariance, attribute possession or Rasch logit ratio measurement as the pathway through which latent therapy-impact claims should be constructed. Without that framework, numerical scores can be generated and analyzed without first establishing that they constitute measures of the latent attribute in question.

This is why the New York result should not be softened by appeals to methodological diversity. The issue is not whether different schools of thought should coexist. Representational measurement is not merely another optional methodology alongside conventional health economics. It defines the conditions under which numerical representations can support quantitative claims. Once those conditions are accepted, every method must either satisfy them or fail them. There is no special exemption for a method because it has been widely used for forty years, endorsed by influential journals, incorporated into graduate training or adopted by professional organizations.

Nor can institutional prestige protect the framework from this challenge. Indeed, the standing of the New York institutions makes the finding more consequential. If some of the most sophisticated academic environments in the United States can produce a 0/17 versus 20/20 profile, then the problem cannot plausibly be dismissed as a local educational weakness. It suggests a deeper epistemic closure within contemporary HTA: the discipline has become highly developed within its inherited analytical framework while remaining largely insulated from the scientific standards capable of challenging the legitimacy of that framework.

That is the essence of program-content inversion. The field has accumulated technical sophistication around the arithmetic of HTA while failing to establish the measurement foundation that should precede that arithmetic. Students are therefore at risk of being trained to calculate before being taught what permits calculation. They may learn how to construct a model without learning whether the quantities entering that model possess the scale properties required for the operations performed. They may become highly proficient in techniques while remaining unequipped to answer the most elementary scientific question: is this a measure?

For graduate education, that is unacceptable. A university should not certify advanced competence in quantitative therapy evaluation if the student has not been taught the standards required to distinguish lawful measurement from numerical assignment. Graduate education should not merely reproduce prevailing professional practice. It should provide students with the knowledge necessary to challenge that practice. The university's responsibility is therefore not satisfied by teaching what HTA agencies, consultants or industry currently use. It must also teach the scientific standards by which those methods can be accepted or rejected.

The New York result also has implications for faculty. Many current faculty members were themselves trained within the legacy framework and may never have encountered representational measurement as a central requirement of quantitative science. That helps explain how the omission arose. It does not justify its continuation. Once the measurement failure has been identified, the epistemic inheritance of faculty cannot be allowed simply to pass to another generation. Faculty must either acquire the necessary measurement knowledge themselves or ensure that students receive it from those who can provide it.

The required response is therefore not incremental curriculum reform. Adding a lecture on scales of measurement while leaving utilities, QALYs, ICERs and reference-case modelling untouched would simply preserve the inversion. Measurement must become the organizing scientific principle of the curriculum. The attribute must be defined first. Its measurement properties must be established. The distinction between manifest and latent attributes must determine the measurement pathway. For manifest attributes, therapy-impact claims require linear ratio measurement. For latent attributes, they require Rasch logit ratio measurement and defensible assessment of attribute possession. Only after lawful measurement has been established should arithmetic proceed.

This transition also changes the destination of HTA education. The objective should no longer be mastery of a toolkit of inherited procedures. It should be the ability to construct therapy-impact claims that are measurable, empirically evaluable, replicable and capable of falsification. That is the route by which quantitative therapy evaluation can contribute to objective knowledge. Anything less risks preserving numerical sophistication without scientific legitimacy.

The New York 0/17 versus 20/20 result is therefore not simply descriptive. It is diagnostic. It identifies a field whose program-content knowledge base is highly developed on the legacy side and effectively empty on the representational-measurement side. The imbalance is so complete that it cannot plausibly be described as an oversight. It reflects a fundamentally inverted scientific architecture.

For New York universities, the question is now unavoidable. Will they continue to reproduce a framework whose measurement foundations have failed, or will they reconstruct graduate education so that measurement determines what arithmetic is permitted? The first option preserves continuity. The second restores quantitative legitimacy.

For students, the question is simpler still. If a program cannot demonstrate that it teaches the scientific foundations required to determine whether therapy-impact claims are actually measures, why enroll?

CONCLUSION: THE CHALLENGE OF TRANSFORMATION

Now that the measurement problem has been exposed, the challenge facing New York 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 New York program-content findings, together with the earlier demonstrations of measurement and curriculum 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 out of the legacy HTA litter box. It cannot simply be put back.

There is therefore no scientific basis for defending the status quo simply because it is established practice. The relevant question is no longer whether utilities, QALYs and economic models have been useful, widely adopted or employed for decades. Longevity, professional endorsement 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 respected. Numerical assignment cannot substitute for measurement. Where these requirements are violated, the resulting arithmetic is inadmissible. No subsequent modelling, sensitivity analysis, statistical refinement or computational sophistication can repair a measurement failure that occurred before the analysis began.

The challenge is consequently one of transformation: how should New York HTA be reconstructed to meet the requirements of lawful measurement? This question carries particular weight given the academic environments represented by Weill Cornell Medicine, NYU Grossman School of Medicine, Columbia University Mailman School of Public Health, the Icahn School of Medicine at Mount Sinai, the University of Rochester Medical Center and the University at Buffalo**.** These institutions educate future researchers and practitioners, undertake methodological research and contribute to health economics, comparative effectiveness, outcomes research, health services research and healthcare policy far beyond New York State. The 0/17 versus 20/20 program-content finding therefore provides an opportunity to reconsider not simply what students are taught, but the scientific order in which they are taught it.

That ordering is the central issue. The New York result does not identify a shortage of analytical sophistication. The 20/20 result demonstrates precisely the opposite. It identifies a highly developed contemporary HTA and health-economics framework without an identifiable prior foundation in the 17 requirements of representational measurement. The problem is therefore not that New York programs need more quantitative methods. It is that the quantitative methods already taught and researched must be subjected to the measurement standards that should have preceded them.

The starting point is straightforward. Representational measurement must become the foundation of HTA rather than an optional addition to the existing curriculum**.** Students must first learn to define the target attribute, understand the constraints imposed by scale type, distinguish manifest from latent attributes, establish the appropriate form of ratio measurement, determine which arithmetic operations are admissible and formulate claims capable of empirical evaluation, replication and falsification. For manifest attributes, this requires linear ratio measurement. For latent attributes, it requires Rasch logit ratio measurement and assessment of attribute possession. Only after these requirements have been satisfied should subsequent statistical analysis, economic evaluation or other quantitative procedures be undertaken.

This transformation does not abandon HTA. It abandons the measurement failure of legacy HTA**.** It places quantitative therapy assessment within the requirements of normal science. New York universities and research centers therefore face a clear choice: continue reproducing an inherited framework in which arithmetic precedes measurement, or reconstruct HTA around lawful measurement in which measurement determines what arithmetic is permitted. The two cannot simply coexist as equivalent scientific approaches because they begin from incompatible premises.

Representational measurement constrains arithmetic; legacy HTA has developed without those constraints.

The responsibility of New York universities is particularly important because graduate education reproduces disciplines. What faculty teach today becomes the knowledge base of tomorrow's researchers, practitioners and future faculty. If another generation of students is taught utilities, QALYs, ICERs and modelling without first being taught the measurement standards required to assess their admissibility, the existing measurement failure is not merely being inherited; it is being actively reproduced**.** University education cannot be reduced to transmitting methods because those methods happen to dominate current professional practice.

Faculty necessarily have the leading educational role in breaking that cycle. This does not require an assumption that instructors have knowingly disregarded representational measurement. Most were themselves educated within contemporary HTA and teach the methodological framework transmitted through universities, textbooks, journals, professional organizations and established research practice. That explains how the epistemic legacy could persist. It cannot justify its continuation once the measurement failure has been exposed. The 0/17 finding indicates the extent to which representational measurement is absent from the publicly presented program-content framework examined.

Transformation must therefore begin with faculty as well as students. Faculty need access to the scientific knowledge and practical tools required to reconsider attributes, scale properties, ratio measurement, admissible transformations, dimensional homogeneity, manifest and latent measurement, Rasch measurement and the construction of evaluable therapy-impact claims. This cannot be accomplished by inserting a single lecture entitled *Measurement* into an otherwise unchanged curriculum. Once measurement precedes arithmetic, that principle must govern everything that follows.

For New York, the choice is consequently more consequential than curriculum revision. These universities can continue transmitting a highly sophisticated 20/20 legacy HTA framework resting upon a 0/17 representational-measurement foundation, or they can use their considerable academic resources to begin its replacement. The measurement standards themselves are not optional and they are not new. What must change is the HTA framework that failed to incorporate them**.**

It is precisely this gap that the Maimon Research nine-unit transformation program is intended to address It is precisely this gap that the Maimon Research nine-unit transformation program is intended to address [1]. 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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[1] Maimon Research. HTA Reconstruction. https://maimonresearch.com/hta-reconstruction-program-and-fees/