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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

NEW ZEALAND: THE ENDORSEMENT OF CURRICULUM INVERSION

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ABSTRACT

An earlier interrogation of the New Zealand health technology assessment (HTA) knowledge base identified a consistent pattern of measurement inversion in which the principles of representational measurement received little recognition while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and reference-case simulation were accepted as though they provided scientifically valid quantitative measures of therapy impact. The present study examines the complementary question of whether this methodological failure is created, transmitted, and sustained through curriculum inversion within the educational knowledge base responsible for preparing New Zealand HTA practitioners.

A standardized large language model interrogation was applied to the New Zealand HTA curriculum knowledge base using ten canonical statements derived from the requirements of representational measurement. These addressed specification of the target attribute, scales of measurement, prior establishment of measurement status, the axioms of representational measurement, unidimensionality, manifest and latent attributes, ratio measurement, and falsifiability. Nine of the ten statements received categorical probabilities of 0.15 or lower. The only strongly endorsed statement was recognition that directly observable outcomes support empirical observation.

The results demonstrate a pronounced inversion of the scientific sequence. Students and practitioners are introduced to utilities, QALYs, patient-reported outcomes, economic evaluation, and decision modelling before being equipped to determine whether the quantities entering these analyses are lawful measures. The failure is sequential. Ordinal health-state responses are valued through preference methods, entered into econometric models, converted into coefficients treated as utility weights, used to generate utility scores, multiplied by time to construct QALYs, divided into costs to create cost-per-QALY ratios, and propagated through simulation models. At each stage, multiplication or division requires ratio measurement, yet ratio measurement has not been established.

The interrogation further identifies the absence of the manifest-latent attribute distinction and the corresponding marginal position of Rasch measurement as central curriculum failures. New Zealand's compact and closely connected academic, professional, and funding environment allows these methodological assumptions to circulate readily between education and practice.

The conclusion is that curriculum inversion provides the educational mechanism through which measurement inversion is reproduced within New Zealand HTA. Incremental methodological reform cannot resolve a failure located at the level of measurement itself. Reconstruction requires curricula founded on representational measurement, explicit target-attribute specification, linear ratio measurement for manifest attributes, Rasch logit ratio measurement for latent attributes, and prospectively evaluable, independently replicable, and empirically falsifiable therapy-impact claims.

INTRODUCTION

The present analysis complements an earlier interrogation of the New Zealand health technology assessment (HTA) knowledge base that examined the extent to which the accepted principles of representational measurement are recognized within contemporary New Zealand HTA [1]. That investigation demonstrated a consistent pattern of measurement inversion across PHARMAC, university-based health economics and HTA activities, and the wider professional knowledge base supporting reimbursement and policy assessment. Representational measurement received little recognition, while multiattribute instruments, utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and reference-case simulation were accepted as though they provided scientifically valid quantitative measures of therapy impact. The present study addresses the complementary question of how this methodological framework is created, transmitted, and sustained through the educational system responsible for preparing successive generations of New Zealand HTA practitioners. It examines whether measurement inversion is accompanied by curriculum inversion.

The present analysis examines the New Zealand HTA curriculum knowledge base through the application of a standardized representational measurement interrogation. Its purpose is not to evaluate individual universities, research groups, government agencies, professional organizations, or teaching programs, but to determine whether the scientific principles required for lawful quantitative measurement are embedded within the educational framework that prepares New Zealand HTA practitioners. The interrogation employs ten canonical curriculum statements derived from the requirements of representational measurement. These encompass specification of the target attribute, the principal scales of measurement, establishment of measurement status before quantitative claims are advanced, the axioms of representational measurement, unidimensionality, the distinction between manifest and latent attributes, the corresponding requirements for ratio measurement, and the requirement that therapy-impact claims be empirically falsifiable. Together, the statements provide a consistent framework for assessing whether New Zealand HTA education is grounded in the scientific conditions required for valid quantitative evaluation.

New Zealand occupies a distinctive position in the international development of HTA. Through PHARMAC and its emphasis on pharmaceutical funding, opportunity cost, comparative value, and budget-constrained decision making, New Zealand has developed one of the most closely observed national approaches to medicine reimbursement. Its universities and research groups have also contributed to health economics, clinical epidemiology, population health, outcomes research, evidence synthesis, and economic evaluation. Because the New Zealand HTA community is relatively small and closely connected, academic teaching, policy practice, consultancy, government service, and professional training reinforce one another particularly strongly. The New Zealand curriculum knowledge base is therefore significant not only because it prepares domestic practitioners but because it sustains the professional assumptions through which HTA methods are interpreted and applied within a compact national decision system.

The central question addressed by this interrogation is whether New Zealand HTA education introduces students and practitioners first to the scientific principles governing measurement before presenting the accepted analytical methods of contemporary HTA. If these foundational concepts receive consistently weak endorsement while utilities, QALYs, cost-effectiveness analysis, patient-reported outcomes, and decision-analytic modelling remain dominant components of the educational framework, the result is curriculum inversion. In such a curriculum, arithmetic precedes measurement rather than following it, technical proficiency is developed before scientific competence, and methodological convention substitutes for prior measurement validation. The New Zealand interrogation therefore seeks to determine whether the educational framework supporting contemporary HTA satisfies the requirements of representational measurement or whether it reproduces the same measurement inversion already identified within the New Zealand HTA knowledge base.

CURRICULUM INVERSION

Curriculum inversion occurs when a curriculum teaches the application of quantitative methods while failing to teach the measurement principles that determine whether those methods are scientifically legitimate. In a scientifically coherent curriculum, measurement precedes arithmetic. Students first learn the nature of attributes, the requirements of representational measurement, the distinctions among nominal, ordinal, interval and ratio scales, and the conditions necessary for valid quantitative claims for manifest and the application of Rasch models for latent attributes [2] [3] [4] . Only then are they introduced to the arithmetic, statistical and modelling procedures that depend upon those measurement properties. Curriculum inversion reverses this sequence. Students learn how to calculate, model and analyze before they learn how to determine whether the quantities entering those analyses are measures. Arithmetic becomes detached from measurement and numerical manipulation is treated as though it were equivalent to quantitative science.

The consequences are profound. A curriculum affected by inversion reproduces a professional culture in which measurement is assumed rather than demonstrated. Concepts such as unidimensionality, dimensional homogeneity, admissible arithmetic, manifest and latent attributes, ratio measurement and Rasch measurement either disappear entirely or are treated as peripheral concerns. Students become proficient in the techniques of economic evaluation, utility assessment, QALY construction and simulation modelling without acquiring the conceptual tools necessary to evaluate the legitimacy of those methods. The result is that the curriculum not only fails to identify measurement errors but actively reproduces them across successive generations of researchers, analysts and decision makers. Curriculum inversion therefore serves as the educational mechanism through which measurement inversion becomes institutionalized within a discipline. In HTA this serves to support administrative decisions for therapy pricing and access.

For this reason, curriculum assessment emerges as a critical component of HTA reconstruction. The objective is not simply to determine whether students are exposed to contemporary HTA methods. Rather, it is to determine whether they are exposed to the foundational concepts that make the evaluation of those methods possible. A curriculum that emphasizes modelling, economic evaluation and decision analysis while neglecting measurement theory will inevitably reproduce the same conceptual limitations observed in current HTA practice.

The curriculum interrogations compelling support for this interpretation. While there is evidence that students and researchers are introduced to outcomes assessment, target attributes and scientific claims, there is little evidence of systematic exposure to scales of measurement, the axioms of representational measurement, unidimensionality, latent attribute measurement or ratio measurement. The concepts most frequently absent from curriculum coverage are precisely those concepts most frequently absent from HTA practice. The relationship is unlikely to be coincidental.

The imperative of measurement inversion therefore extends beyond criticism of existing methods. It points directly to the need for educational reconstruction. If HTA is to move toward a framework based on lawful measurement, evaluable claims and empirical falsification, then curriculum reform must accompany methodological reform. The widespread and consistent pattern of measurement inversion revealed by the interrogations suggests that reconstruction cannot begin with policy guidance or analytical techniques alone. It must begin with the curriculum. Until students and researchers are introduced to the foundations of measurement science, the conditions that created measurement inversion will continue to be reproduced throughout the HTA community.

THE NEW ZEALAND HTA CURRICULUM KNOWLEDGE BASE

The New Zealand health technology assessment (HTA) curriculum knowledge base does not reside within a single nationally prescribed academic program. It is distributed across universities, health economics and population health teaching, research groups, government assessment processes, professional training, methodological guidance, and the wider literature supporting pharmaceutical funding and healthcare decision making. Collectively, these sources establish the concepts, analytical methods, and professional expectations that define competence within contemporary New Zealand HTA.

New Zealand universities occupy a central position within this knowledge base. Teaching and research relevant to HTA are located principally within health economics, public health, population health, epidemiology, pharmacy, clinical research, and health services research. The Universities of Auckland and Otago have particularly visible roles, although HTA-related teaching and research are not confined to programs explicitly identified as health technology assessment. Students may encounter economic evaluation, cost-effectiveness analysis, quality-of-life assessment, evidence synthesis, and decision modelling through postgraduate degrees, specialist courses, research supervision, or participation in applied health research.

The curriculum knowledge base is therefore dispersed but conceptually consistent. Teaching commonly emphasizes comparative effectiveness, economic evaluation, cost-effectiveness and cost-utility analysis, utilities, QALYs, patient-reported outcomes, decision trees, Markov models, uncertainty, sensitivity analysis, and evidence synthesis. These methods reflect the dominant international reference-case paradigm while also responding to the distinctive requirements of New Zealand's publicly funded healthcare system. The analytical environment surrounding PHARMAC exerts a particularly important indirect educational influence because practitioners are prepared to operate within a funding system in which comparative clinical benefit, economic evaluation, opportunity cost, and budget consequences are established components of decision making.

Professional knowledge is also transmitted through movement between universities, government, consultancy, healthcare organizations, and pharmaceutical industry roles. In a relatively small

HTA community, these connections are particularly important. Academic teaching informs professional practice, practitioners contribute to teaching and research, and funding requirements influence the analytical skills regarded as professionally valuable. The result is a closely connected learning environment in which methodological assumptions can be rapidly transmitted and strongly reinforced.

What is striking, however, is the limited visibility of representational measurement as an organizing framework within this educational environment. The accessible curriculum knowledge base provides little indication that students are systematically required to begin therapy assessment by specifying the target attribute and establishing its measurement status. Nominal, ordinal, interval, and ratio scales may be encountered within general research-methods teaching, but their properties are not visibly imposed as constraints on the arithmetic undertaken within HTA. The axioms of representational measurement, dimensional homogeneity, and admissible transformations do not appear to provide the scientific foundation upon which economic evaluation is constructed.

The distinction between manifest and latent attributes is similarly absent as an organizing principle. Directly observable outcomes such as survival, hospital admissions, adverse events, treatment discontinuation, and resource utilization are readily recognized. Pain, fatigue, functioning, wellbeing, and other patient-reported outcomes are also prominent. Yet these two classes of attributes are not systematically distinguished according to their fundamentally different measurement requirements. Observable events and numerical scores derived from ordinal questionnaire responses are instead incorporated within a common analytical framework.

This omission helps explain the marginal position of Rasch measurement within mainstream New Zealand HTA education. Rasch methods may appear within specialist psychometric or outcomes research, but they are not established as the required measurement framework for estimating possession of latent attributes. Students can therefore encounter patient-reported outcomes, multiattribute instruments, utility valuation, and QALYs without first confronting the scientific problem of latent attribute measurement.

The New Zealand HTA curriculum knowledge base is consequently technically sophisticated and closely connected to professional practice. Its weakness lies not in the absence of analytical methods but in the sequence in which competence is developed. Students and practitioners are introduced to instruments, utility values, QALYs, arithmetic, and decision models before the measurement status of the relevant attributes has been established. In New Zealand's closely integrated HTA environment, this has particular significance: the same methodological assumptions can pass readily from professional practice to teaching and from teaching to the next generation of practitioners. It is this reversal of the scientific sequence that defines curriculum inversion and provides the educational mechanism through which measurement inversion is reproduced within New Zealand HTA.

INTERROGATING THE NEW ZEALAND CURRICULUM KNOWLEDGE BASE

The objective of large language model (LLM) curriculum interrogation differs from that of previous HTA knowledge-based practice assessments. Earlier interrogations focused on whether institutions recognized the requirements of representational measurement and the standards necessary for quantitative claims. Curriculum interrogation asks a different question. Are faculty, students and researchers exposed to the concepts necessary to understand and apply those standards? The focus shifts from methodological outputs to educational inputs. Rather than examining what faculty, students and researchers do, attention is directed to what they are taught and what they know.

The importance of this distinction should not be underestimated. Educational programs do not merely transmit technical skills. They define the conceptual framework through which future practitioners understand evidence, measurement and scientific inquiry. Concepts that are absent from the curriculum are unlikely to emerge spontaneously in research practice. Equally, concepts that are emphasized repeatedly become part of the intellectual assumptions that shape subsequent analysis have never been systematically incorporated into HTA teaching and research training.

For this reason, the curriculum interrogation was designed around a series of canonical statements intended to identify the presence or absence of foundational measurement concepts. These statements were deliberately elementary. The purpose was not to assess advanced methodological knowledge but to determine whether faculty, students and researchers are likely to encounter the principles that underpin lawful quantitative claims. The resulting framework begins with the concept of an attribute as the object of measurement and proceeds through target attribute specification, scales of measurement, representational measurement, unidimensionality, manifest and latent attributes, ratio measurement and falsifiable claims. Together, these statements define the minimum intellectual foundations required for a measurement-based approach to therapy assessment in education.

These statements are:

- **An attribute is the specific outcome of interest in a therapy assessment.**
- **Every therapy assessment begins with specification of the target attribute.**
- **The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis.**
- **The measurement status of a target attribute must be established before quantitative claims can be advanced.**
- **The axioms of representational measurement underpin quantitative claims.**
- **Attributes must be demonstrated to be unidimensional before measurement is possible.**
- **A manifest attribute is directly observable and capable of supporting empirical observation.**
- **A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute.**
- **Manifest and latent attributes require different forms of ratio measurement.**

- **Therapy impact claims must be falsifiable.**

These ten statements form a logical sequence:

Attribute → Target Attribute → Scales of Measurement → Measurement Status → Representational Measurement → Unidimensionality → Manifest Attribute → Latent Attribute → Ratio Measurement → Falsifiable Claims

The categorical probabilities reported in this assessment are intended as indicators of the extent to which a concept is represented within the curriculum knowledge base. They should not be interpreted as precise statistical estimates but as measures of the likelihood that a student, researcher or professional exposed to that knowledge base would encounter, recognize and subsequently endorse the canonical statement. In practical terms, the probability reflects the visibility and prominence of a concept within the educational environment associated with a research center or policy agency.

A high probability indicates that the concept is well represented within curriculum materials, research outputs and educational activities and is therefore likely to be familiar to students and researchers. Conversely, a low probability suggests that the concept is absent, only weakly represented, or occupies a peripheral position within the curriculum knowledge base. Students exposed to such an environment would therefore be unlikely to recognize the concept as an important component of HTA education and practice.

The probabilities should be viewed comparatively rather than in isolation. Their principal value lies in identifying patterns of curriculum coverage across institutions and concepts. In particular, low probabilities associated with scales of measurement, representational measurement, unidimensionality and ratio measurement indicate that these topics are unlikely to form a substantial part of the educational experience of the average student. The resulting profile provides an indication of curriculum strengths, deficiencies and potential areas for reconstruction.

NEW ZEALAND AND CURRICULUM INVERSION

The New Zealand curriculum knowledge base demonstrates a pronounced pattern of curriculum inversion. Nine of the ten canonical statements receive probabilities of 0.15 or lower. Six receive probabilities of 0.10 or lower, while the three statements most directly concerned with the foundations of representational measurement receive the minimum probability of 0.05. The result is an educational framework in which the established methods of economic evaluation and decision analysis are substantially more visible than the scientific principles required to determine whether their constituent quantities are lawful measures.

The only strongly endorsed statement is the recognition of manifest attributes as directly observable. This is consistent with the importance placed within New Zealand health research on clinical outcomes, mortality, hospital use, treatment effects, costs and resource utilization. These outcomes can be counted, timed or otherwise observed empirically. The curriculum knowledge base therefore recognizes observable outcomes, but it does not appear to locate them within an explicit theory of manifest attributes or connect them systematically to the requirements of linear ratio measurement.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: NEW ZEALAND KNOWLEDGE BASE

CANONICAL STATEMENT	CATEGORICAL PROBABILITY	NORMALIZED LOGIT
An attribute is the specific outcome of interest in a therapy assessment	0.15	-1.75
Every therapy assessment begins with specification of the target attribute	0.10	-2.20
The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis	0.15	-1.75
The measurement status of a target attribute must be established before quantitative claims can be advanced	0.05	-2.50
The axioms of representational measurement underpin quantitative claims	0.05	-2.50
Attributes must be demonstrated to be unidimensional before measurement is possible	0.10	-2.20
A manifest attribute is directly observable and capable of supporting empirical observation	0.80	+1.40
A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute	0.15	-1.75
Manifest and latent attributes require different forms of ratio measurement	0.05	-2.50
Therapy impact claims must be falsifiable	0.10	-2.20

Recognition of the target attribute is weak. New Zealand HTA education and professional training appear more likely to begin with a decision problem, intervention, comparator, evidence base or economic model than with the prior specification of the particular attribute intended to be measured. Outcomes may be identified for inclusion in an assessment, but this is not equivalent to defining the attribute independently of the questionnaire, utility instrument or model used to represent it. Consequently, the assessment framework is established before the object of measurement has been adequately specified.

The limited endorsement of the principal scales of measurement reflects a distinction between general methodological familiarity and their application within HTA. Nominal, ordinal, interval and ratio scales may be encountered in statistics or research-methods education. There is little indication, however, that students are required to apply these scale distinctions to utility values, QALYs, incremental cost-effectiveness ratios or modelled outcomes. The curriculum therefore permits arithmetic operations without first establishing that the relevant scales support them.

The minimum probabilities assigned to prior establishment of measurement status and to the axioms of representational measurement identify the central deficiency. The accessible educational environment gives little prominence to order, additivity, cancellation, solvability, invariance, admissible transformations or dimensional homogeneity as prerequisites for quantitative claims. Students encounter numbers as model inputs without first being required to establish whether those numbers are measures. Measurement is assumed because numerical values are available.

Unidimensionality also receives weak endorsement. New Zealand HTA draws upon patient-reported outcomes, quality-of-life instruments and multiattribute preference systems, yet the requirement that a single attribute must be demonstrated before measurement can occur is not evident as an organizing curriculum principle. Different dimensions of health may therefore be combined into a score or utility without first establishing a unidimensional empirical structure.

The latent-attribute statement receives a probability of only 0.15. Pain, fatigue, physical functioning, wellbeing and similar outcomes are clearly understood as requiring indirect observation through patient responses. What is not systematically recognized is that these are latent attributes whose possession requires a formal measurement model. The curriculum appears to move from ordinal questionnaire responses to scores, preference values and utilities without requiring proof that the underlying attribute has been measured.

This explains the minimum probability assigned to the distinction between the measurement requirements of manifest and latent attributes. There is little evidence that New Zealand HTA education is organized around linear ratio measurement for directly observable attributes and Rasch logit ratio measurement for latent attributes. Observable outcomes, questionnaire scores, utility values and modelled quantities are instead incorporated into a common analytical framework despite their different measurement status.

Falsifiability also receives weak endorsement. New Zealand health-economic analysis gives substantial attention to modelling, uncertainty, sensitivity analysis and alternative analytical perspectives. Contemporary New Zealand methodological work continues to emphasize Markov models, probabilistic sensitivity analysis and cost-effectiveness decision frameworks. These procedures explore the behavior of models under changing assumptions, but they do not necessarily produce prospectively specified therapy-impact claims that can be independently replicated and empirically falsified.

Overall, the New Zealand results indicate that students and practitioners are introduced to the arithmetic and modelling architecture of contemporary HTA before they are introduced to the measurement principles required to evaluate it. The curriculum knowledge base supports technical proficiency in economic evaluation, utility assessment, QALYs, modelling and decision analysis, while providing little systematic preparation in representational measurement, ratio-scale requirements, latent-attribute measurement or falsification.

The result is curriculum inversion. The educational framework does not merely omit several independent concepts. It reproduces a sequence in which ordinal health-state responses, preference valuations, econometric utility weights, utility scores, QALYs, cost-per-QALY ratios and reference-case simulations are accepted in succession without establishing the ratio measurement required for multiplication and division. Each failed operation supplies the numerical input for the next.

STATEMENT-BY-STATEMENT REVIEW

1. An attribute is the specific outcome of interest in a therapy assessment

Categorical probability: 0.15 | Normalized logit: -1.75

The New Zealand HTA curriculum knowledge base provides weak endorsement of the concept of an attribute as the specific outcome of interest in therapy assessment. Clinical outcomes, endpoints, health states, quality of life, patient-reported outcomes, costs and measures of effectiveness are widely recognized, but these categories do not substitute for formal specification of the attribute to be measured. The educational framework appears more likely to begin with an intervention, comparator, decision problem, funding question or economic model than with an explicit theory of attributes. The low probability therefore reflects the absence of the attribute as the organizing starting point for quantitative assessment.

2. Every therapy assessment begins with specification of the target attribute

Categorical probability: 0.10 | Normalized logit: -2.20

There is little evidence that New Zealand HTA education requires specification of the target attribute as the mandatory first step in an assessment. Curricula and professional training commonly emphasize the population, intervention, comparator, clinical evidence, economic consequences and decision context. These elements are important, but they do not answer the prior scientific question: what precisely is the therapy intended to change? Outcomes may be chosen for inclusion in an evaluation without being defined independently of the instrument, utility system or model used to represent them. The strongly negative logit indicates that the analytical framework generally precedes formal specification of the object of measurement.

3. The principal scales of measurement have different properties and support different forms of analysis

Categorical probability: 0.15 | Normalized logit: -1.75

Nominal, ordinal, interval and ratio scales may be encountered within general statistics, epidemiology or research-methods education. The interrogation, however, provides little evidence that their implications are systematically applied within New Zealand HTA teaching. In particular, students do not appear to be routinely required to establish whether utility values, patient-reported scores or modelled outcomes support addition, multiplication, division, ratios or percentage change. Scale terminology may therefore be familiar while the restrictions imposed by scale properties remain disconnected from HTA practice. This allows arithmetic to proceed without prior demonstration that the proposed operations are admissible.

4. The measurement status of a target attribute must be established before quantitative claims can be advanced

Categorical probability: 0.05 | Normalized logit: -2.50

This statement receives minimal endorsement within the New Zealand curriculum knowledge base. Numerical outcomes, questionnaire scores, preference values, utilities and model parameters are introduced as inputs to analysis without a prior requirement to establish that they are measures. The existence of a numerical value is effectively treated as sufficient authority for arithmetic and modelling. The distinction between a number and a measure is therefore largely absent. This minimum probability identifies one of the central characteristics of curriculum inversion: students are taught to manipulate numerical outputs before establishing the measurement status of the attributes those outputs are intended to represent.

5. The axioms of representational measurement underpin quantitative claims

Categorical probability: 0.05 | Normalized logit: -2.50

Representational measurement is effectively absent as an organizing framework for New Zealand HTA education. There is little visible recognition of order, additivity, solvability, cancellation, invariance, admissible transformations or dimensional homogeneity as prerequisites for quantitative claims. Students instead encounter comparative effectiveness, utility assessment, QALYs, economic evaluation and decision modelling as established analytical practices. Without the axiomatic framework, they lack the criteria required to distinguish lawful measurement from numerical construction. The minimum probability therefore represents a foundational educational failure rather than the absence of an optional specialist topic.

6. Attributes must be demonstrated to be unidimensional before measurement is possible

Categorical probability: 0.10 | Normalized logit: -2.20

Unidimensionality receives little endorsement as a universal condition for measurement. It may be recognized in specialist psychometric or instrument-development contexts, but it does not appear to govern mainstream HTA education. This is particularly significant because patient-reported outcomes, quality-of-life instruments and multiattribute preference systems combine observations across different domains. Mobility, pain, anxiety, self-care and usual activities may be brought together within a single score or utility without first demonstrating that they represent one attribute. The curriculum consequently permits numerical aggregation to substitute for the prior establishment of a unidimensional measurement structure.

7. A manifest attribute is directly observable and capable of supporting empirical observation

Categorical probability: 0.80 | Normalized logit: +1.40

This is the only strongly endorsed statement. New Zealand HTA and health-services research clearly recognize outcomes that can be directly observed, counted or timed. These include mortality, survival, hospital admissions, emergency visits, adverse events, treatment discontinuation, medication use, costs and resource utilization. This strength reflects New Zealand's substantial traditions in clinical research, epidemiology, administrative data and health-services evaluation. The limitation is that such outcomes are not generally identified explicitly as manifest attributes within a representational-measurement framework. Their observability is recognized, but the implications for lawful linear ratio measurement are not systematically developed.

8. A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute

Categorical probability: 0.15 | Normalized logit: -1.75

The New Zealand curriculum knowledge base shows limited recognition of the measurement problem presented by latent attributes. Pain, fatigue, functioning, wellbeing, treatment satisfaction and quality of life are understood as outcomes requiring patient report or indirect assessment. What is largely absent is the stronger requirement that possession of these attributes must be estimated through a formal measurement model satisfying the conditions required for quantitative measurement. The educational sequence appears to move from ordinal questionnaire responses to summed scores, preference values or utilities without first demonstrating that the underlying latent attribute has been measured.

9. Manifest and latent attributes require different forms of ratio measurement

Categorical probability: 0.05 | Normalized logit: -2.50

The distinction between linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes is essentially absent from the New Zealand curriculum knowledge base. Directly observable outcomes, patient-reported scores, preference values, utility scores and modelled outcomes are incorporated into a common analytical environment despite possessing fundamentally different measurement properties. The curriculum does not appear to begin by classifying the target attribute and then identifying the lawful form of measurement required. The minimum probability represents a major structural failure: New Zealand HTA education lacks a coherent measurement strategy connecting the nature of the attribute to the form of ratio measurement needed to support quantitative claims.

10. Therapy-impact claims must be falsifiable

Categorical probability: 0.10 | Normalized logit: -2.20

Falsifiability receives little explicit recognition as a mandatory property of therapy-impact claims. New Zealand HTA practice and education give substantial attention to evidence quality, uncertainty, sensitivity analysis, scenario analysis, model validation and interpretation. These procedures, however, are not equivalent to specifying prospectively the empirical result that would demonstrate that a therapy-impact claim had failed. A model can be rerun under alternative assumptions without exposing the underlying claim to direct empirical rejection. The low probability therefore reflects an educational environment in which uncertainty surrounding numerical constructions is emphasized more strongly than prospective evaluation, independent replication and falsification.

OVERALL INTERPRETATION

The statement-by-statement interrogation identifies a highly asymmetric New Zealand HTA curriculum knowledge base. Directly observable outcomes are strongly recognized, reflecting New Zealand's strengths in clinical research, epidemiology, health-services evaluation and administrative data. Almost every principle required to transform observations into lawful quantitative claims, however, receives weak or minimal endorsement.

The lowest probabilities occur at the foundational points where measurement science should govern HTA: establishment of measurement status before quantitative claims, the axioms of representational measurement, and the distinction between the ratio measurement requirements of manifest and latent attributes. Unidimensionality, target-attribute specification and falsifiability also receive little endorsement. These omissions remove the intellectual framework required to determine whether utilities, QALYs, cost-per-QALY ratios and reference-case simulations are scientifically admissible.

The results therefore indicate that New Zealand HTA education supports technical proficiency more strongly than scientific competence. Students and practitioners may learn how to interpret utility values, calculate QALYs, construct economic models and assess uncertainty without first learning how to determine whether the quantities entering those operations are measures. Curriculum inversion provides the educational mechanism through which measurement inversion is reproduced.

The failure is also sequential rather than a collection of isolated omissions. Ordinal responses to multidimensional health-state instruments are valued through preference methods, entered into econometric models, converted into coefficients treated as utility weights, applied to generate utility scores, multiplied by time to create QALYs, divided into costs to create cost-per-QALY ratios and propagated through reference-case simulations. Multiplication and division require ratio measures, yet ratio measurement is not established at the critical stages. Each inadmissible operation therefore supplies the numerical input for the next.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF NEW ZEALAND HTA

A central finding of the New Zealand curriculum interrogation is the absence of any explicit framework distinguishing manifest from latent attributes and the corresponding measurement requirements that follow from this distinction. This omission is particularly significant because the distinction between manifest and latent attributes is not a methodological refinement but one of the foundational concepts of representational measurement. Without it there is no coherent basis for determining how therapy outcomes should be measured, what constitutes a lawful quantitative claim, or whether the arithmetic applied within HTA is scientifically admissible.

Manifest attributes are directly observable. Their existence and magnitude can be established through empirical observation without the need for an intervening measurement model. Examples include survival time, hospital admissions, emergency department visits, medication adherence, treatment discontinuation, adverse events, laboratory values, and healthcare resource utilization. These attributes are observable phenomena that can be counted, timed, or otherwise recorded directly. When properly specified, they support linear ratio measures with a meaningful zero and lawful arithmetic operations. The scientific task is straightforward: define the attribute, establish the unit of observation, specify the observation period, and subject the resulting claim to empirical evaluation and independent replication.

Latent attributes present a fundamentally different measurement problem. Pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, health confidence, and need fulfilment cannot be observed directly. Their existence must be inferred from observable indicators, typically responses to structured questionnaire items. Consequently, latent attributes require a measurement model capable of estimating possession of the attribute while satisfying the axioms of representational measurement. Within HTA this requirement is met through Rasch measurement, which provides a logit ratio measure possessing the properties required for lawful quantitative inference.

The importance of this distinction cannot be overstated. Manifest attributes require linear ratio measures, whereas latent attributes require Rasch logit ratio measures. These are the only two measurement frameworks capable of supporting lawful quantitative claims regarding therapy impact. The distinction therefore determines the entire measurement strategy adopted within HTA.

The interrogation suggests that the New Zealand curriculum knowledge base does not recognize this distinction as an organizing principle for HTA education. Instead, outcomes are grouped within broad categories such as patient-reported outcomes, quality of life, utility measurement, clinical effectiveness, economic evaluation, and value assessment. These categories are descriptively useful but scientifically inadequate because they fail to distinguish between directly observable attributes and attributes requiring a measurement model. The measurement requirements governing each type of outcome consequently remain obscured.

Once this distinction disappears, virtually any numerical output can be treated as though it possesses equivalent measurement status. Utility scores, preference weights, composite indices, symptom scales, observational counts, and resource-use measures are brought together within the same analytical framework despite possessing fundamentally different measurement properties. The consequence is a loss of measurement discipline in which numerical construction is mistaken for quantitative measurement.

For New Zealand this omission has particular significance. The national HTA environment is relatively compact, with close connections among university teaching, health economics research, PHARMAC, government service, consultancy, and pharmaceutical-sector practice. These connections allow methodological assumptions to circulate rapidly and become mutually reinforcing. If the distinction between manifest and latent attributes is absent from the curriculum, the same absence is likely to persist across research, reimbursement analysis, and professional decision making. Until this distinction becomes an organizing principle of New Zealand HTA education, curriculum inversion will continue to reproduce measurement inversion throughout the national HTA system.

THE ABSENCE OF RASCH

The absence of the manifest-latent distinction also explains the near absence of Rasch measurement within the New Zealand curriculum knowledge base. If latent attributes are not explicitly recognized as requiring a measurement model, there is no perceived need to introduce the one measurement framework capable of constructing lawful quantitative measures of latent attribute possession. Instead, ordinal questionnaire responses are transformed into utility scores, composite indices, and quality-adjusted life years (QALYs) and subsequently treated as though measurement has already been achieved. The measurement problem is therefore bypassed rather than solved.

From the perspective of curriculum design, this represents a classic example of curriculum inversion. Students are introduced to utilities, QALYs, patient-reported outcomes, health economic evaluation, and reference-case modelling before they are taught to distinguish between manifest and latent attributes. Consequently, they are never encouraged to ask the fundamental scientific question that should precede every HTA assessment: What is the target attribute, is it manifest or latent, and which lawful form of ratio measurement is required?

For New Zealand this omission is particularly significant because HTA and economic evaluation occupy an important position in decisions concerning the funding and assessment of pharmaceuticals and other healthcare interventions within a publicly funded healthcare system. The influence of PHARMAC has created a professional environment in which comparative value, economic evaluation, and model-based decision analysis are established components of funding assessment. The interrogation suggests that the New Zealand curriculum knowledge base has adopted these methodological conventions without first establishing the scientific foundations of measurement. Until the distinction between manifest and latent attributes becomes an organizing principle of New Zealand HTA education, curriculum inversion will continue to reproduce measurement inversion throughout teaching, research, and policy evaluation.

This places Rasch in a unique position. Rasch is not simply another psychometric technique competing with item response theory, PROMIS, utility instruments, or preference-based scoring systems. It addresses an entirely different scientific problem. Its purpose is to determine whether ordinal observations can be transformed into a quantitative measure of possession of a latent attribute. In doing so, it provides the only established framework capable of demonstrating whether the conditions required for measurement have been satisfied.

The distinction is fundamental. Patient-reported outcomes begin with ordinal responses to questionnaire items describing pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, need fulfilment, and other latent attributes. These responses provide information about order but not quantity. Arithmetic performed directly on ordinal observations cannot create measurement. Summed scores, averages, weighted algorithms, utility values, and preference functions remain numerical constructions unless it has first been demonstrated that the underlying latent attribute has been measured. Numerical manipulation is not measurement.

Rasch measurement was developed precisely to solve this problem. Through the conjoint calibration of persons and items, the Rasch model estimates the location of individuals on a latent continuum while simultaneously testing whether the observations satisfy the conditions required for lawful measurement. Unidimensionality, specific objectivity, invariance, item fit, response-category functioning, local independence, and differential item functioning are not optional methodological refinements. They are the empirical conditions that must be satisfied before a claim regarding possession of a latent attribute can be advanced. Rasch therefore provides both the measurement model and the empirical tests necessary to determine whether measurement has actually been achieved.

The interrogation indicates that this perspective is absent from the New Zealand curriculum knowledge base. Students and practitioners are introduced to patient-reported outcomes, utilities, quality-of-life instruments, preference weights, QALYs, and economic evaluation without first confronting the measurement problem these constructs are intended to solve. The educational sequence moves directly from ordinal responses to scoring systems, utility algorithms, and economic models. The essential intermediate step of demonstrating that a latent attribute has been measured is effectively bypassed.

This omission has profound implications. Without Rasch measurement, latent attributes remain unmeasured. Utility scores, composite indices, and preference algorithms may generate numerical outputs, but they do not establish that the underlying attribute has been measured. The existence of a number should never be confused with the existence of a measure. Nevertheless, the New Zealand HTA framework proceeds as though this distinction does not exist. Students consequently learn how utilities are generated, how QALYs are constructed, and how economic models are populated, yet they are not taught how latent attributes themselves can be measured. The curriculum therefore introduces numerical representations of patient benefit before introducing the scientific framework required to justify those representations. This is curriculum inversion in its clearest form.

For New Zealand, the compact nature of the HTA community gives this omission additional importance. Academic teaching, health economics research, professional practice, and funding assessment are closely connected. A measurement assumption embedded in one part of this system can readily be reproduced throughout the others. The absence of Rasch measurement is therefore not simply a gap in specialist psychometric teaching. It represents the absence of the measurement framework required to evaluate latent therapy outcomes across the wider HTA system. Until this gap is addressed, curriculum inversion will continue to sustain the broader pattern of measurement inversion identified within New Zealand HTA.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN NEW ZEALAND

The companion interrogation of the New Zealand HTA knowledge base demonstrated that contemporary health technology assessment in New Zealand is characterized by measurement inversion. The accepted principles of representational measurement receive little recognition, while utilities, QALYs, cost-effectiveness analysis, and reference-case modelling continue to be treated as though they provide scientifically valid quantitative measures of therapy impact. The present study has addressed the complementary question of how such a framework has been created, sustained, and transmitted across successive generations of practitioners. The answer is curriculum inversion.

The interrogation demonstrates that the New Zealand HTA curriculum knowledge base introduces students and practitioners to the methods of contemporary HTA before introducing them to the scientific principles required to evaluate those methods. Educational emphasis is placed upon comparative effectiveness, economic evaluation, utilities, QALYs, decision modelling, evidence synthesis, patient-reported outcomes, and funding assessment rather than upon specification of the target attribute, representational measurement, admissible arithmetic, unidimensionality, manifest and latent attributes, Rasch measurement, dimensional homogeneity, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification. Graduates therefore acquire technical competence in applying the contemporary HTA framework without first acquiring the scientific framework necessary to determine whether it supports lawful quantitative claims.

For New Zealand, this conclusion has important implications. New Zealand universities and research groups have established substantial expertise in clinical epidemiology, population health, health economics, health services research, outcomes research, and economic evaluation. New Zealand has also attracted international attention through PHARMAC and its distinctive approach to pharmaceutical funding, prioritization, and budget-constrained decision making. The interrogation indicates, however, that the educational framework supporting contemporary New Zealand HTA has adopted and reinforced the analytical conventions of the international economic-evaluation paradigm without first embedding the scientific principles of representational measurement. Curriculum inversion has consequently become the mechanism through which measurement inversion is reproduced. Utilities, QALYs, cost-effectiveness ratios, and simulation models retain a central position despite depending upon quantities that fail the accepted requirements for lawful measurement.

This conclusion leaves no room for incremental reform. A framework whose constituent quantities fail the axioms of representational measurement cannot be rescued through improved modelling, better utility instruments, more sophisticated statistical methods, expanded real-world evidence, richer administrative health data, or increasingly elaborate simulation techniques. None of these developments can create measurement where measurement does not exist. Arithmetic cannot rescue quantities that are not measures. Decades of methodological refinement have failed to resolve this problem because the problem lies beneath the methodology itself, in the absence of lawful measurement.

The implications for New Zealand universities are therefore direct. Continuing to educate students in the construction and application of economic and decision models without first teaching the scientific principles governing lawful measurement is incompatible with the central purpose of higher education. Universities exist to advance objective knowledge rather than perpetuate analytical traditions whose measurement foundations cannot support quantitative claims. Students should certainly understand the historical importance of utilities, QALYs, patient-reported outcome instruments, cost-effectiveness analysis, and reference-case modelling, but they should understand them as examples of a paradigm that failed to satisfy the accepted standards governing quantitative science. They should not be taught that these constructs provide valid measures of therapy impact because they do not.

The implications extend beyond the universities. PHARMAC and the wider New Zealand funding and policy environment depend upon practitioners trained to construct, review, and interpret economic evaluations and modelled claims. University researchers, health economists, consultants, government analysts, and industry specialists operate within a relatively compact professional community. Curriculum inversion therefore creates a particularly close methodological system. Universities teach the methods expected in funding assessment; researchers refine and apply those methods; practitioners construct analyses within the accepted framework; and institutional demand reinforces the curriculum. The same methodological assumptions circulate repeatedly between education and practice. At no point is there a requirement to return to the prior scientific question: are the quantities being manipulated lawful measures?

The only scientifically defensible path forward is reconstruction. Every HTA assessment should begin with explicit specification of the target attribute. Manifest attributes should be evaluated through lawful linear ratio measures. Latent attributes should be evaluated through Rasch logit ratio measures that satisfy the axioms of representational measurement. Every quantitative claim should be accompanied by a prospective protocol specifying the attribute, measurement method, comparator, evaluation period, replication strategy, and conditions for empirical falsification. Measurement must precede arithmetic in every assessment without exception.

Taken together, the companion interrogations of measurement inversion and curriculum inversion demonstrate that the methodological framework underpinning New Zealand HTA has reached its intellectual limit. It has undoubtedly contributed to structured funding assessment, evidence synthesis, prioritization, and administrative decision making, yet it has failed to establish the scientific legitimacy of the quantities upon which its quantitative claims depend. That framework has no scientific future because it rests upon measurement impossibilities. Its place is no longer at the centre of HTA education but in the history of the discipline as an instructive example of how methodological sophistication can evolve independently of measurement science.

New Zealand now faces a clear choice. It can continue to reproduce measurement inversion through a curriculum that teaches arithmetic before measurement and modelling before the specification of measurable attributes, or it can reconstruct HTA around the requirements of quantitative science. The future of New Zealand HTA depends not upon refining the existing paradigm but upon replacing it with one founded on representational measurement, lawful quantitative inference, and prospectively evaluable, replicable, and falsifiable claims regarding therapy impact.

To facilitate this transition, Maimon Research LLC has developed a comprehensive nine-unit HTA Reconstruction Program [5]. The program provides a systematic introduction to representational measurement, the theory of attributes, the principal scales of measurement, admissible arithmetic, dimensional homogeneity, manifest and latent attributes, Rasch logit ratio measurement, protocol development, and the construction of evaluable, replicable, and falsifiable claims regarding therapy impact. Its purpose is not to modify the existing reference-case paradigm but to replace it with a scientific framework in which measurement once again precedes arithmetic.

The program has been designed for universities, HTA agencies, reimbursement organizations, research centers, professional societies, pharmaceutical companies, and health economists seeking a transition from assumption-driven modelling to scientifically defensible measurement. It provides a structured pathway for professional development while establishing the competencies required for the next generation of HTA practitioners. In this way, it offers not simply a critique of the existing paradigm but a practical route toward the reconstruction of HTA as a measurement-based scientific discipline.

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