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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

AUSTRALIA: THE ENDORSEMENT OF CURRICULUM INVERSION

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ABSTRACT

A companion interrogation of the Australian health technology assessment (HTA) knowledge base demonstrated a consistent pattern of measurement inversion in which the principles of representational measurement receive little recognition while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and reference-case simulation models are accepted as though they provide 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 environment responsible for preparing successive generations of Australian HTA practitioners. The hypothesis examined is curriculum inversion: the teaching of arithmetic, statistical analysis, and modelling before establishing the measurement status of the quantities to which these methods are applied.

The Australian HTA curriculum knowledge base was interrogated using ten canonical statements derived from the requirements of representational measurement. These addressed attributes and target-attribute specification, scales of measurement, prior establishment of measurement status, the axioms of representational measurement, unidimensionality, manifest and latent attributes, their distinct requirements for ratio measurement, and falsifiability of therapy-impact claims. Categorical endorsement probabilities and normalized logits were assigned to indicate the visibility of each concept within the accessible curriculum knowledge base.

The results demonstrate a pronounced pattern of curriculum inversion. Nine of the ten canonical statements received endorsement probabilities of 0.20 or lower, with seven at 0.10 or lower. The only strongly endorsed concept was recognition of directly observable manifest attributes. Minimal endorsement was identified for establishing measurement status before quantitative claims, representational measurement, unidimensionality, the distinction between measurement requirements for manifest and latent attributes, and falsifiability. Rasch measurement was effectively absent as the required framework for estimating possession of latent attributes.

The findings indicate that Australian HTA education develops substantial technical competence in economic evaluation, utilities, QALYs, patient-reported outcomes, and decision modelling without first establishing the scientific conditions required for lawful quantitative claims. Curriculum inversion therefore provides the educational mechanism through which measurement inversion is reproduced. Reconstruction requires a curriculum founded on target-attribute specification, linear ratio measurement for manifest attributes, Rasch logit ratio measurement for latent attributes, admissible arithmetic, and prospectively evaluable, replicable, and falsifiable claims. Measurement must precede arithmetic.

INTRODUCTION

The present analysis complements an earlier interrogation of the Australian health technology assessment (HTA) knowledge base that examined the extent to which the accepted principles of representational measurement are recognized within contemporary Australian HTA [1]. That investigation demonstrated a consistent pattern of measurement inversion across the

Pharmaceutical Benefits Advisory Committee (PBAC) and leading academic health economics and HTA research centers. 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 Australian HTA practitioners. It examines whether measurement inversion is accompanied by curriculum inversion.

The present analysis examines the Australian HTA curriculum knowledge base through the application of a standardized representational measurement interrogation. Its purpose is not to evaluate individual universities, research centers, government agencies, or teaching programs, but to determine whether the scientific principles required for lawful quantitative measurement are embedded within the educational framework that prepares Australian 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 Australian HTA education is grounded in the scientific conditions required for valid quantitative evaluation.

Australia occupies a particularly important position in the international development of HTA. Through the early incorporation of economic evaluation into pharmaceutical reimbursement and the influential role of the PBAC, Australia helped establish the use of comparative economic evidence as a formal component of national reimbursement decision making. Australian universities and research centers subsequently developed internationally recognized expertise in health economics, economic evaluation, clinical epidemiology, outcomes research, patient-reported outcomes, decision modelling, and evidence synthesis. Australian academics have contributed substantially to the development and dissemination of contemporary HTA methodology, while graduates trained within these institutions have entered government, academia, consultancy, pharmaceutical industry, and reimbursement practice. The Australian curriculum knowledge base is therefore significant not simply because it prepares domestic practitioners. It has contributed to the wider professional and methodological framework through which contemporary HTA has been taught and applied.

The central question addressed by this interrogation is whether Australian 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 Australian 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 Australian 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 AUSTRALIAN HTA CURRICULUM KNOWLEDGE BASE

The Australian health technology assessment (HTA) curriculum knowledge base does not reside within a single national teaching program or prescribed curriculum. It is distributed across universities, health economics and HTA research centers, government assessment processes, professional training activities, methodological guidance, short courses, and the wider academic literature used to prepare practitioners for work in economic evaluation and reimbursement. Collectively, these sources establish the concepts, analytical methods, and professional expectations that define competence within contemporary Australian HTA.

Australian universities occupy a central position within this knowledge base. Major centres at the University of Technology Sydney, Monash University, the University of Adelaide, the University of Melbourne, the University of Queensland, and Griffith University contribute to teaching and research in health economics, economic evaluation, outcomes research, evidence synthesis, and decision modelling. Their academic activities are complemented by related programs and individual investigators at other Australian universities. Students may encounter HTA through postgraduate health economics programs, public health degrees, pharmacy education, epidemiology, outcomes research, or specialist methodological training rather than through a single degree explicitly designated as an HTA qualification.

The curriculum knowledge base is therefore characterized by methodological diversity but substantial conceptual consistency. Teaching commonly emphasizes comparative effectiveness, economic evaluation, cost-effectiveness and cost-utility analysis, measurement and valuation of health outcomes, multiattribute preference instruments, utilities, QALYs, decision trees, Markov models, extrapolation, sensitivity analysis, and uncertainty. These methods reflect the analytical requirements encountered in Australian reimbursement practice and the wider international reference-case paradigm. The PBAC framework consequently exerts an important indirect educational influence because students and practitioners are prepared to operate within a professional environment in which economic evidence and model-based assessment are established components of reimbursement decision making.

Professional knowledge is also transmitted through research participation, consultancy, government service, pharmaceutical industry experience, workshops, short courses, conferences, and methodological publications. Australian HTA practitioners frequently move between academic, policy, consulting, and industry environments. This circulation reinforces a common methodological vocabulary and creates continuity between what is taught, what is researched, and what is required in professional practice. The curriculum knowledge base should therefore be understood as a professional learning environment extending beyond formal university course descriptions.

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 evidence that students are systematically required to begin therapy assessment by specifying the target attribute and establishing its measurement status. The properties of nominal, ordinal, interval, and ratio scales are not visibly integrated into HTA as constraints on admissible arithmetic. The axioms of representational measurement, dimensional homogeneity, and unidimensionality do not appear to provide the scientific foundation upon which quantitative analysis is constructed.

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

This omission helps explain the marginal position of Rasch measurement within mainstream Australian HTA education. Rasch methods may appear within specialist psychometric and 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, utilities, and QALYs without first being required to confront the scientific problem of latent attribute measurement.

The Australian HTA curriculum knowledge base is consequently extensive, technically sophisticated, and closely connected to professional practice. Its weakness lies not in the absence of analytical methods but in the sequence in which quantitative competence is constructed. Students are introduced to instruments, scores, utilities, arithmetic, and models before the measurement status of the relevant attributes has been established. It is this reversal of the scientific sequence that defines curriculum inversion and provides the educational mechanism through which measurement inversion is reproduced across Australian HTA.

INTERROGATING THE AUSTRALIAN 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.

AUSTRALIA AND CURRICULUM INVERSION

The Australian curriculum knowledge base demonstrates a pronounced pattern of curriculum inversion (Table 1). Nine of the ten canonical statements receive endorsement probabilities of 0.20 or lower. Seven receive probabilities of 0.10 or lower, including the three statements most directly concerned with the foundations of quantitative science: establishing measurement status before advancing claims, recognizing the axioms of representational measurement and distinguishing the measurement requirements of manifest and latent attributes.

The only strongly endorsed statement is the recognition of manifest attributes as directly observable. This result is consistent with the strength of Australian teaching and research in clinical epidemiology, health-services research, trials and outcomes assessment. Australian programs clearly recognize outcomes that can be observed, counted or timed. Their courses discuss clinical outcomes, costs, resource use and effectiveness data and teach students how these observations enter economic evaluations.

Recognition of observable outcomes, however, is not embedded within an explicit representational-measurement framework. The curriculum materials generally move from costs and outcomes to analysis, modelling and decision support. Melbourne's practical economic-evaluation course, for example, progresses through cost and outcome analysis, decision-analytic and Markov models and sensitivity analysis. Its modelling material describes transforming intermediate outcomes into projected final outcomes and using models to evaluate uncertainty. This is technically sophisticated teaching, but the published descriptions do not identify prior establishment of measurement status as a compulsory analytical stage.

The low endorsement of target-attribute specification reflects a similar pattern. Australian curricula commonly begin with an intervention, comparator, clinical study, economic question or decision problem. Outcomes are then selected for inclusion in the evaluation. This is not equivalent to establishing a precisely defined attribute independently of the instrument, score or model used to represent it. The available curriculum materials provide limited evidence that students are required to begin every assessment by asking what specific attribute is intended to change and what form of measurement that attribute permits.

Scale terminology may be encountered through statistics and research-methods education, which supports a probability of 0.15 rather than complete absence. What appears missing is systematic application of scale constraints to HTA. The curricula emphasize analyzing outcomes, assigning utilities, constructing QALYs and modelling cost-effectiveness, but do not visibly require students to demonstrate that the underlying numerical scales support the proposed operations. Australian teaching material explicitly presents QALY construction, economic modelling and uncertainty analysis as standard components of evaluation.

The two statements receiving the minimum probability of 0.05, measurement status before quantitative claims and representational measurement as the foundation of those claims identify the core curriculum deficiency. The accessible materials provide no indication that order, additivity, solvability, cancellation, invariance, admissible transformations and dimensional homogeneity form the required starting point for HTA analysis. The analytical sequence is therefore predominantly numerical rather than measurement-based.

Unidimensionality also receives weak endorsement. It may be recognized in specialist psychometric or instrument-development contexts, but it is not evident as a universal prerequisite for measurement within mainstream HTA teaching. This is significant because Australian health economics includes substantial work on quality of life, PROMs, preferences and multiattribute instruments. These areas are treated as sources of outcomes or utility values rather than as latent-attribute measurement problems requiring prior demonstration of unidimensionality.

The curriculum knowledge base shows some recognition that pain, functioning, wellbeing and related outcomes are not observed in the same way as hospital admissions or survival. This justifies an endorsement probability of 0.20 for the latent-attribute statement. What remains largely absent is the stronger requirement that possession of a latent attribute must be established through a measurement model. PROMs, preference elicitation, quality-of-life valuation and utility algorithms are visible; Rasch measurement as the necessary foundation for measuring latent attribute possession is not.

The weakest structural result is the near absence of the distinction between linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes. Australian curriculum materials bring observable outcomes, questionnaire scores, preferences, utilities and modelled results into a common evaluative framework. They do not appear to organize HTA education around two fundamentally different measurement pathways.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: AUSTRALIAN KNOWLEDGE BASE

CANONICAL STATEMENT	CATEGORICAL PROBABILITY	NORMALIZED LOGIT
An attribute is the specific outcome of interest in a therapy assessment	0.20	-1.40
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	0.85	+1.75
A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute	0.20	-1.40
Manifest and latent attributes require different forms of ratio measurement	0.05	-2.50
Therapy impact claims must be falsifiable	0.10	-2.20

Finally, falsifiability receives only marginal endorsement. Australian programs teach uncertainty analysis, sensitivity analysis, model checking and interpretation, but these do not amount to requiring prospectively specified therapy-impact claims that can fail against empirical observation. Modelling evaluates how outputs change when assumptions or parameters change; it does not necessarily expose the underlying therapy claim to independent replication and falsification.

Overall, the results indicate that Australian students are taught the established instruments and arithmetic of contemporary HTA before they are taught the scientific principles required to determine whether those instruments generate measures. The curriculum strongly supports technical proficiency but provides little evidence of the representational-measurement competencies required to recognize measurement failure. The categorical probabilities are structured endorsement judgements based on the accessible curriculum knowledge base; they are not percentages of courses or statistically estimated population parameters.

STATEMENT-BY-STATEMENT REVIEW

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

Categorical probability: 0.20 | Normalized logit: -1.40

The Australian HTA curriculum knowledge base provides limited endorsement of the concept of an attribute as the specific outcome of interest in a therapy assessment. Clinical outcomes, endpoints, health states, patient-reported outcomes, quality of life, and measures of effectiveness are widely discussed, but these categories do not substitute for explicit specification of the attribute to be measured. The educational framework generally begins with an intervention, clinical question, economic evaluation, or decision problem rather than with a formal theory of attributes. The low probability reflects the absence of attribute specification as an organizing principle 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 Australian HTA education requires explicit specification of the target attribute as the mandatory first step in therapy assessment. Curricula commonly emphasize population, intervention, comparator, outcomes, evidence requirements, and model structure. These are important elements of assessment but do not answer the prior measurement question: what precisely is the therapy intended to change? The strongly negative logit indicates that the analytical framework is generally introduced before the object of measurement has been formally established. This is a defining characteristic of curriculum inversion.

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 statistics, epidemiology, and research methods teaching. The interrogation, however, provides little evidence that their mathematical implications are systematically integrated into HTA education. In particular, students are not routinely required to determine whether numerical inputs support means, differences, multiplication, ratios, or percentage change before undertaking economic analysis. Scale terminology may therefore be recognized without the associated constraints on admissible arithmetic. This separation between scale classification and quantitative practice permits numerical operations to proceed without prior measurement justification.

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 Australian curriculum knowledge base. Numerical outcomes, questionnaire scores, utility values, preference weights, and model parameters are routinely introduced as inputs to quantitative analysis without a prior requirement to establish their measurement status. The distinction between a numerical value and a measure is largely absent. Students consequently learn how numbers are analyzed and combined before determining whether those numbers represent quantities capable of supporting the proposed arithmetic. The minimum probability identifies one of the clearest manifestations of measurement inversion within Australian HTA education.

5. The axioms of representational measurement underpin quantitative claims

Categorical probability: 0.05 | Normalized logit: -2.50

Representational measurement is effectively absent as a foundational framework for mainstream Australian HTA education. There is little evidence that order, additivity, solvability, cancellation, invariance, admissible transformations, and dimensional homogeneity are systematically presented as conditions governing quantitative claims. Students are instead introduced directly to statistical analysis, utility measurement, QALY construction, and economic modelling. The absence of the axiomatic framework removes the scientific criteria required to distinguish lawful measurement from numerical construction. The strongly negative logit therefore represents a foundational curriculum deficiency rather than a minor omission in methodological content.

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

Categorical probability: 0.10 | Normalized logit: -2.20

Unidimensionality receives limited recognition as a universal requirement for measurement. It may appear within specialist psychometric or instrument-development contexts, but it does not provide an organizing principle for mainstream HTA teaching. This is particularly significant given the prominence of multiattribute health instruments, quality-of-life constructs, and composite patient-reported outcomes. Multiple dimensions may be combined to generate scores or utility values without first demonstrating that a single attribute is being measured. The curriculum therefore permits numerical aggregation to substitute for establishment of a unidimensional measurement structure.

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

Categorical probability: 0.85 | Normalized logit: +1.75

This is the only strongly endorsed canonical statement. Australian HTA education is firmly grounded in clinical epidemiology, health services research, trials, and outcomes assessment, where directly observable events and outcomes are routinely identified. Survival time, hospital admissions, emergency department visits, adverse events, treatment discontinuation, and resource utilization are readily recognized as empirically observable phenomena. The limitation is that these outcomes are not generally classified explicitly as manifest attributes within a representational measurement framework. Recognition of direct observation is strong, but recognition of its implications for linear ratio measurement and lawful arithmetic is substantially weaker.

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

Categorical probability: 0.20 | Normalized logit: -1.40

The Australian curriculum knowledge base provides limited recognition of the measurement problem presented by latent attributes. Pain, fatigue, physical functioning, treatment satisfaction, and quality-of-life constructs are widely recognized as outcomes requiring patient report or indirect assessment. What is largely missing is the stronger requirement that possession of a latent attribute must be estimated through a measurement model satisfying the conditions required for quantitative measurement. Questionnaire scores, composite indices, preference weights, and utility algorithms are commonly treated as numerical representations of patient outcomes without first establishing 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 Australian curriculum knowledge base. Observable outcomes, patient-reported scores, preference values, utilities, and modelled outcomes are commonly incorporated within a shared analytical framework despite possessing fundamentally different measurement properties. The curriculum does not appear to begin by classifying the target attribute and then selecting the appropriate form of ratio measurement. The minimum probability identifies a major structural failure: Australian HTA education lacks a coherent measurement strategy linking attribute type to the form of measurement required.

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 quantitative therapy-impact claims. Australian HTA education gives substantial attention to uncertainty, sensitivity analysis, scenario analysis, model validation, and interpretation of economic results. These activities, however, are not equivalent to specifying in advance the empirical conditions under which a therapy-impact claim would be rejected. Reference-case models may explore alternative assumptions without exposing the underlying claim to direct empirical failure. The low probability reflects an educational framework in which management of model uncertainty is emphasized more strongly than the construction of prospectively evaluable, independently replicable, and falsifiable claims.

OVERALL INTERPRETATION

The statement-by-statement interrogation demonstrates a highly asymmetric Australian curriculum knowledge base. Directly observable outcomes are strongly recognized, reflecting Australia's substantial strengths in clinical epidemiology, health services research, and empirical outcomes assessment. Almost every principle required to convert observations into lawful quantitative claims, however, receives weak or minimal endorsement.

The pattern is not random. The lowest probabilities occur precisely at the points where measurement science should constrain contemporary HTA practice: establishment of measurement status before quantitative claims, the axioms of representational measurement, unidimensionality, and the distinction between the ratio measurement requirements of manifest and latent attributes. These omissions remove the intellectual framework required to challenge utilities, QALYs, multiattribute instruments, and reference-case simulation at their measurement foundations.

The Australian curriculum knowledge base therefore appears capable of producing graduates with substantial technical proficiency in economic evaluation and decision analysis while providing little systematic preparation in the scientific principles required to determine whether the quantities entering those analyses are measures. The results support the conclusion that curriculum inversion is the educational mechanism through which measurement inversion is reproduced within Australian HTA. Students are taught how to undertake the accepted arithmetic of the discipline before they are equipped to determine whether that arithmetic is scientifically admissible.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF AUSTRALIAN HTA

A central finding of the Australian 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 Australian 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, 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.

THE ABSENCE OF RASCH

The absence of the manifest-latent distinction also explains the near absence of Rasch measurement within the Australian 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 submission: What is the target attribute, is it manifest or latent, and which lawful form of ratio measurement is required?

For Australia this omission is particularly significant because health technology assessment plays an increasingly important role in decisions concerning the adoption, reimbursement, pricing, and evaluation of pharmaceuticals, medical devices, and healthcare interventions within a publicly funded healthcare system. The interrogation suggests that the Australian curriculum knowledge base has adopted the methodological conventions of contemporary HTA without first establishing the scientific foundations of measurement. Until the distinction between manifest and latent attributes becomes the organizing principle of Australian HTA education, curriculum inversion will continue to reproduce measurement inversion throughout Australian 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 Australian 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 and economic models. The essential intermediate step 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 construct has been measured. The existence of a number should never be confused with the existence of a measure. Nevertheless, Australian HTA proceeds as though this distinction does not exist. Students consequently learn how utilities are generated, how QALYs are constructed, and how reference-case 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.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN AUSTRALIA

The companion interrogation of the Australian HTA knowledge base demonstrated that contemporary health technology assessment in Australia 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 Australian 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 reimbursement methodology 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 constructing the contemporary HTA framework without first acquiring the scientific framework necessary to determine whether that framework supports lawful quantitative claims.

For Australia, this conclusion has important implications. Australian universities and research centers have earned an international reputation for clinical epidemiology, evidence-based medicine, health economics, outcomes research, registry-based research, and health technology assessment. Australia was also an early international leader in the formal application of economic evaluation to pharmaceutical reimbursement through the Pharmaceutical Benefits Advisory Committee. The interrogation indicates, however, that the educational framework supporting contemporary Australian HTA has adopted and reinforced the analytical conventions of the reference-case paradigm without first embedding the scientific principles of representational measurement. The consequence is that curriculum inversion has become the mechanism through which measurement inversion is reproduced within Australian HTA. Utilities, QALYs, cost-effectiveness ratios, and reference-case simulation models continue to occupy a central position in professional education 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 linked 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 Australian universities are therefore direct. Continuing to educate students in the construction and application of reference-case 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. The PBAC and the broader Australian reimbursement framework depend upon a continuing supply of practitioners trained to construct, review, and interpret cost-effectiveness models. Australian HTA research centres reinforce this framework through research, postgraduate education, consultancy, and participation in policy development. Curriculum inversion therefore creates a closed methodological system. Universities teach the methods expected by reimbursement agencies; research centres refine and apply those methods; agencies require submissions constructed within the same framework; and the resulting institutional demand reinforces the curriculum. 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 submission 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 Australian HTA has reached its intellectual limit. It has undoubtedly succeeded in strengthening evidence synthesis and standardizing administrative decision making, yet it has failed to establish the scientific legitimacy of the quantities upon which those decisions depend. That framework has no scientific future because it rests upon measurement impossibilities. Its place is no longer at the center of HTA education but in the history of the discipline as an instructive example of how methodological sophistication can evolve independently of measurement science.

Australia 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 Australian 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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