MAIMON RESEARCH LLC

ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

CANADA: THE ENDORSEMENT OF CURRICULUM INVERSION

Paul C Langley PhD Adjunct Professor, College of Pharmacy, University of Minnesota, Minneapolis, MN

LOGIT WORKING PAPER No 1550 JULY 2026

www.maimonresearch.com

Tucson AZ

ABSTRACT

A series of large language model interrogations of the Canadian health technology assessment (HTA) knowledge base has identified a consistent pattern of measurement inversion across national agencies, academic research centers, universities, professional activities, and the wider methodological framework supporting reimbursement and policy assessment. The present study addresses the complementary question of how this framework is created, transmitted, and sustained through the educational environment responsible for preparing successive generations of Canadian HTA practitioners. It examines the extent of curriculum inversion.

The interrogation indicates that the principles required for lawful quantitative measurement receive little recognition within the Canadian HTA curriculum knowledge base. Representational measurement, scale properties, admissible arithmetic, dimensional homogeneity, unidimensionality, ratio measurement, the distinction between manifest and latent attributes, and Rasch measurement occupy marginal positions. In contrast, utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, patient-reported outcomes, and reference-case simulation models are taught and applied as though their measurement foundations had already been established. The educational sequence is therefore inverted: arithmetic and modelling precede measurement.

This inversion is not a collection of independent curriculum omissions. It supports a sequence of dependent measurement errors. Ordinal health-state responses are incorporated into preference-elicitation exercises and econometric models without first establishing measurement status. Model coefficients are interpreted as utility weights with ratio properties that have not been demonstrated. Utilities are multiplied by ratio-scale time to construct QALYs; costs are divided by QALYs; and these numerical constructions are propagated through increasingly elaborate reference-case simulation models. At each critical stage, the arithmetic requires ratio measurement. That requirement is largely absent from the Canadian HTA curriculum knowledge base.

The near absence of Rasch measurement further leaves Canadian HTA without a defensible framework for measuring possession of latent attributes such as pain, fatigue, functioning, and need fulfilment. Scores, utilities, and preference algorithms are consequently mistaken for measures.

The conclusion is that curriculum inversion provides the mechanism through which measurement inversion is reproduced within Canadian HTA. Reconstruction requires explicit specification of target attributes, linear ratio measurement for manifest attributes, Rasch logit ratio measurement for latent attributes, measurement before arithmetic, and prospectively evaluable, independently replicable, and empirically falsifiable claims regarding therapy impact. The future of Canadian HTA depends upon replacing curriculum inversion with professional competence grounded in measurement science.

INTRODUCTION

The present analysis complements an earlier interrogation of the Canadian health technology assessment (HTA) knowledge base that examined the extent to which the accepted principles of representational measurement are recognized within contemporary Canadian HTA [1]. That investigation demonstrated a consistent pattern of measurement inversion across Canada's Drug Agency, provincial reimbursement and assessment systems, university-based health economics and HTA research centers, and the wider professional knowledge base supporting formulary and policy decisions. 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 Canadian HTA practitioners. It examines whether measurement inversion is accompanied by curriculum inversion.

The present analysis examines the Canadian 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, 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 Canadian 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 Canadian HTA education is grounded in the scientific conditions required for valid quantitative evaluation.

Canada occupies an especially important position in the international development of HTA. Canadian universities and research centers have contributed substantially to clinical epidemiology, evidence-based medicine, health economics, pharmacoeconomics, outcomes research, patient-reported outcomes, health-utility measurement, economic evaluation, and decision analysis. Canadian investigators were influential in the development and dissemination of multiattribute health-status systems and utility-based approaches to health assessment, while federal and provincial agencies helped institutionalize the use of comparative clinical and economic evidence in reimbursement decision making. Canada therefore represents more than a national adopter of the contemporary HTA paradigm. It has been one of the countries in which that paradigm was developed, refined, taught, and given professional legitimacy.

The Canadian curriculum knowledge base is consequently broad and institutionally distributed. HTA-related education is located across medicine, pharmacy, public health, epidemiology, health economics, health policy, outcomes research, and decision science. It is reinforced through university teaching, research centers, government assessment, consultancy, industry practice, professional societies, journals, and methodological guidance. This creates a closely connected educational and professional environment in which the methods accepted by reimbursement agencies influence what is taught, while university teaching and research provide the practitioners and analytical frameworks upon which those agencies depend.

The central question addressed by this interrogation is whether Canadian 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, health-utility systems, 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 Canadian 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 Canadian 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 CANADIAN HTA CURRICULUM KNOWLEDGE BASE

he Canadian health technology assessment (HTA) curriculum knowledge base is extensive, institutionally distributed, and deeply embedded within the country's health research and policy environment. It does not reside within a single nationally prescribed HTA curriculum. Rather, it is created through university teaching, specialist graduate programs, health economics and epidemiology training, research centers, government assessment agencies, professional organizations, methodological guidance, journals, and the continuing movement of practitioners between academic, public-sector, consultancy, and pharmaceutical-industry roles. Collectively, these sources establish the concepts, methods, and professional competencies associated with contemporary Canadian HTA.

Canadian universities occupy a central position within this knowledge base. HTA-related education is distributed across faculties and departments of medicine, pharmacy, public health, epidemiology, health economics, health policy, outcomes research, and decision science. McMaster University, the University of Toronto, the University of British Columbia, the University of Alberta, the University of Calgary, and other major institutions have contributed substantially to the methodological environment surrounding clinical epidemiology, evidence-based medicine, health economics, patient-reported outcomes, health-utility assessment, and economic evaluation. Students may encounter HTA through formal courses, graduate degrees, research supervision, specialist methodological training, and participation in applied assessment projects.

The curriculum knowledge base is therefore broad but conceptually consistent. Teaching commonly emphasizes comparative effectiveness, evidence synthesis, cost-effectiveness and cost-utility analysis, utility assessment, QALYs, patient-reported outcomes, decision trees, Markov models, uncertainty, sensitivity analysis, and economic modelling. These methods are reinforced by the requirements of Canada's Drug Agency and provincial reimbursement and formulary systems. The skills regarded as professionally valuable are consequently closely aligned with the analytical framework expected in Canadian reimbursement assessment.

Canada differs from many smaller HTA systems because it has not simply imported this framework. Canadian academics and research groups have contributed directly to its development. The country's traditions in clinical epidemiology and evidence-based medicine helped shape international approaches to evidence assessment. Canadian investigators also played a major role in health-status classification, utility measurement, pharmacoeconomics, and outcomes research. The development and application of the Health Utilities Index provides a particularly important example of Canada's contribution to the international utility paradigm. The Canadian curriculum knowledge base therefore reflects methods that Canadian institutions have themselves helped create, refine, and legitimize.

What is striking, however, is the limited visibility of representational measurement as an organizing framework within this extensive educational environment. Students are not systematically required to begin therapy assessment by specifying the target attribute and establishing its measurement status. Nominal, ordinal, interval, and ratio scales may be introduced within general research-methods or statistics courses, but the restrictions imposed by these scales are not consistently carried forward into utility assessment, QALY construction, or cost-effectiveness analysis. The axioms of representational measurement, admissible transformations, dimensional homogeneity, and the requirement that measurement precede arithmetic occupy little visible space within mainstream HTA education.

The distinction between manifest and latent attributes is similarly absent as an organizing principle. Survival, hospital admissions, adverse events, resource utilization, and treatment discontinuation are recognized as observable outcomes. Pain, fatigue, functioning, cognition, emotional wellbeing, and quality of life are recognized as patient-reported or indirectly assessed outcomes. Yet these two classes of attributes are not systematically separated according to their fundamentally different measurement requirements. Observable events, questionnaire scores, preference weights, and utility values are incorporated within a common analytical framework despite possessing different measurement properties.

This omission also explains the marginal position of Rasch measurement within mainstream Canadian HTA education. Rasch methods are present within specialist psychometric and outcomes research, but they are not established as the required framework for measuring possession of latent attributes. Students can therefore become proficient in patient-reported outcome assessment, utility elicitation, QALY construction, and economic modelling without first confronting the scientific problem of latent attribute measurement.

The Canadian HTA curriculum knowledge base is consequently technically sophisticated and professionally influential. Its weakness lies not in the absence of analytical methods but in the sequence through which competence is developed. Students and practitioners learn how to generate, combine, and model numerical values before establishing whether those values are lawful measures. Because Canadian universities, research centers, assessment agencies, and professional practice are closely connected, these assumptions are repeatedly transmitted between education and application. Curriculum inversion therefore provides the mechanism through which measurement inversion is reproduced and sustained within Canadian HTA.

INTERROGATING THE CANADIAN 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.

CANADA AND CURRICULUM INVERSION

The Canadian HTA curriculum knowledge base demonstrates a pronounced pattern of curriculum inversion (Table 1). Nine of the ten canonical statements receive probabilities of 0.25 or lower. Five 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 profile indicates that Canadian students and practitioners are exposed extensively to the methods of economic evaluation and outcomes research but receive little systematic preparation in the measurement principles required to determine whether the quantities entering those methods are scientifically admissible.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: CANADIAN 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	0.15	-1.75
The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis	0.20	-1.40
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	0.15	-1,75
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	0.25	-1.10
Manifest and latent attributes require different forms of ratio measurement	0.05	-2.50
Therapy impact claims must be falsifiable	0.10	-2,20

The only strongly endorsed statement is recognition of manifest attributes as directly observable. This reflects Canada's major traditions in clinical epidemiology, health-services research, administrative data, clinical trials, and evidence-based medicine. Survival, hospital admissions, adverse events, resource utilization, treatment discontinuation, and other observable outcomes are readily recognized as empirical evidence. Canada's academic health-sciences programs have long emphasized health research methodology, evidence assessment, health policy, and clinical outcomes.

Recognition of attributes and target attributes is somewhat stronger than in several smaller national curriculum knowledge bases. Canadian outcomes research frequently refers to constructs, domains, endpoints, health states, and patient-important outcomes. Nevertheless, these concepts are not generally organized around the requirement that every assessment begin with specification of one target attribute whose measurement properties must be established independently of the instrument or analytical method selected. An outcome chosen for inclusion in a study is not necessarily a formally specified attribute.

The principal scales of measurement are likely to be encountered in statistics, epidemiology, psychometrics, psychology, and research-methods education. This supports a probability of 0.20. The problem lies in their application. There is little indication that the limitations imposed by nominal, ordinal, interval, and ratio scales are carried forward systematically into utility measurement, QALY construction, cost-effectiveness ratios, or decision modelling. Students may know the terminology without being required to enforce the arithmetic constraints associated with each scale.

The minimum probability assigned to establishing measurement status before quantitative claims identifies the central inversion. Canadian teaching commonly proceeds from questionnaire responses, health-state classifications, preference values, utility scores, costs, and clinical outcomes to statistical or economic analysis. It does not ordinarily require a prior demonstration that each numerical input is a lawful measure capable of supporting the proposed arithmetic.

The axioms of representational measurement are similarly absent as an organizing curriculum framework. Order, additivity, solvability, cancellation, invariance, admissible transformations, and dimensional homogeneity do not appear to provide the required foundation for Canadian HTA education. The discipline instead begins with accepted methodologies such as cost-effectiveness analysis, cost-utility analysis, health-state valuation, and decision modelling. This leaves students without the scientific framework needed to distinguish measurement from numerical construction.

Unidimensionality receives limited recognition. Canada possesses substantial expertise in psychometrics, patient-reported outcomes, utility measurement, and health-status instruments. The Health Utilities Index, developed at McMaster University, classifies health across multiple domains and generates preference-based utility values used in QALY calculations. Yet the broader curriculum does not appear to treat demonstration of a single unidimensional attribute as a universal prerequisite for quantitative measurement. Multiple domains can therefore be combined within a health-state system and assigned a single utility value without first establishing that one attribute is being measured.

Canada receives a somewhat higher probability of 0.25 for recognition of latent attributes. Canadian researchers have made substantial contributions to patient-reported outcomes, health-related quality of life, utility assessment, and psychometric research. There is therefore greater awareness that pain, functioning, cognition, emotion, and wellbeing cannot be observed in the same manner as mortality or hospital use. What remains weak is the requirement that possession of a latent attribute must be established through a formal measurement model satisfying the axioms of measurement. Recognition that an outcome is indirectly observed does not establish that it has been measured.

The distinction between linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes receives the minimum probability. Canadian teaching does not appear to organize therapy assessment around these two separate measurement pathways. Observable outcomes, questionnaire scores, preference weights, utility values, QALYs, and modelled outcomes are incorporated within a common analytical framework despite possessing fundamentally different measurement properties.

Falsifiability also receives weak endorsement. Canada has exceptional traditions in clinical epidemiology, evidence-based medicine, controlled trials, systematic review, and critical appraisal. These emphasize empirical testing and uncertainty, but they do not necessarily require that every therapy-impact claim be formulated prospectively with explicit conditions for rejection. Sensitivity analysis and model validation explore the behavior of assumptions and outputs; they are not substitutes for independent replication and empirical falsification.

OVERALL ASSESSMENT

The Canadian result is particularly significant because Canada was not merely a passive recipient of the contemporary HTA paradigm. Canadian academics contributed directly to its development through clinical epidemiology, pharmacoeconomics, health-utility research, outcomes measurement, and economic decision analysis. The Health Utilities Index emerged from McMaster University, while Canadian health economists helped institutionalize the use of cost-effectiveness evidence in provincial pharmaceutical decision making.

Canada therefore represents a case of curriculum construction rather than simple curriculum inheritance. Its universities and research centers helped create, refine, teach, and legitimize the methods that now dominate HTA. The interrogation indicates, however, that this methodological sophistication was not accompanied by an equivalent commitment to representational measurement.

The result is a curriculum capable of producing substantial technical expertise in utility assessment, QALY construction, economic evaluation, statistical analysis, and decision modelling while failing to provide the measurement competence required to evaluate the legitimacy of those methods. Technical proficiency precedes scientific validation.

The failure is sequential. Ordinal responses to multidimensional health-state questionnaires are converted into health-state descriptions; selected descriptions receive preference values; these values enter econometric models; estimated coefficients are interpreted as utility weights; utility scores are multiplied by time to generate QALYs; costs are divided by incremental QALYs; and the resulting numerical constructions are propagated through reference-case simulations. Multiplication and division require ratio measures, yet ratio measurement is not established at the critical stages.

Curriculum inversion therefore supplies the educational mechanism through which Canadian measurement inversion is reproduced. The Canadian case is especially consequential because the country helped construct the international utility and economic-evaluation framework. The architects of the paradigm created a technically sophisticated analytical system without embedding the measurement principles required to determine whether its constituent operations were lawful.

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 Canadian HTA curriculum knowledge base provides limited endorsement of the concept of an attribute as the specific outcome of interest in therapy assessment. Clinical endpoints, health states, domains, patient-important outcomes, constructs, utilities, and measures of effectiveness are widely discussed, but these categories do not substitute for explicit specification of the attribute to be measured. Canadian teaching commonly begins with a clinical or policy question, intervention, comparator, outcome set, economic evaluation, or decision problem rather than with a formal theory of attributes. The low probability reflects the absence of the attribute as the mandatory organizing starting point for quantitative assessment.

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

Categorical probability: 0.15 | Normalized logit: -1.75

There is limited evidence that Canadian HTA education requires explicit target-attribute specification as the first step in every assessment. Students are commonly taught to define populations, interventions, comparators, outcomes, perspectives, time horizons, and model structures. These are necessary components of evaluation, but they do not answer the prior measurement question: what precisely is the therapy intended to change? An outcome selected for inclusion in a study is not necessarily a formally specified attribute. The negative logit indicates that the analytical framework is generally constructed before the object of measurement and its required properties have been independently established.

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

Categorical probability: 0.20 | Normalized logit: -1.40

Nominal, ordinal, interval, and ratio scales are likely to be encountered in Canadian statistics, epidemiology, psychology, psychometrics, and research-methods teaching. The interrogation, however, indicates little systematic application of their constraints within HTA. Students may recognize the terminology while not being required to determine whether utility scores, patient-reported outcomes, QALYs, or model outputs support addition, multiplication, division, ratios, or percentage change. Scale classification is therefore separated from analytical practice. This permits arithmetic to proceed without prior demonstration that the relevant measurement scale authorizes the proposed operations.

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 Canadian curriculum knowledge base. Questionnaire scores, preference values, utility scores, clinical outcomes, and model parameters are introduced as quantitative inputs without a prior requirement to establish their measurement status. Numerical availability is effectively treated as sufficient authority for analysis. The distinction between a number and a measure is consequently obscured. This minimum probability identifies the central curriculum inversion: students learn how to analyze and combine numerical values before determining whether those values represent quantities capable of supporting the proposed arithmetic.

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 Canadian HTA education. There is little visible recognition of order, additivity, solvability, cancellation, invariance, admissible transformations, or dimensional homogeneity as conditions governing quantitative claims. Students instead encounter cost-effectiveness analysis, utility assessment, QALY construction, statistical estimation, and decision modelling as established methodologies. Without the axiomatic framework, they lack the scientific criteria required to distinguish lawful measurement from numerical construction. The minimum probability represents a foundational curriculum failure rather than the omission of an optional advanced topic.

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

Categorical probability: 0.15 | Normalized logit: -1.75

Unidimensionality receives limited recognition as a universal prerequisite for measurement. Canada has substantial expertise in psychometrics, patient-reported outcomes, health-status classification, and instrument development, so the concept is not wholly absent. It may be examined in specialist methodological settings. However, it does not appear to govern mainstream HTA teaching, particularly where multiattribute health instruments combine mobility, pain, cognition, emotion, self-care, and other domains into a single utility value. The curriculum therefore permits multidimensional aggregation without first demonstrating that one attribute is being measured.

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. Canadian clinical epidemiology, health-services research, trials, administrative-data analysis, and evidence-based medicine clearly recognize outcomes that can be directly observed, counted, or timed. Survival, hospital admissions, emergency visits, adverse events, treatment discontinuation, medication use, and resource utilization are readily accepted as empirical outcomes. The limitation is that these are not generally classified explicitly as manifest attributes within a representational-measurement framework. Their observability is recognized, but the connection to lawful linear ratio measurement is not systematically developed.

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

Categorical probability: 0.25 | Normalized logit: -1.10

Canada receives somewhat stronger endorsement of this statement because of its extensive traditions in health-related quality of life, patient-reported outcomes, psychometrics, utility assessment, and health-status measurement. Canadian researchers clearly recognize that pain, functioning, emotion, cognition, wellbeing, and related constructs cannot be observed in the same manner as mortality or hospital use. What remains weak is the requirement that possession of a latent attribute must be established through a formal measurement model satisfying the axioms of measurement. Recognition of indirect observation does not demonstrate that lawful measurement has been achieved.

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 Canadian HTA curriculum knowledge base. Directly observable outcomes, questionnaire scores, preference weights, utility values, QALYs, and modelled quantities are incorporated into a common analytical framework despite possessing fundamentally different measurement properties. Canadian education does not appear to begin by classifying the target attribute and then identifying the corresponding form of ratio measurement. The minimum probability identifies a structural failure in the curriculum's measurement strategy.

10. Therapy-impact claims must be falsifiable

Categorical probability: 0.10 | Normalized logit: -2.20

Falsifiability receives weak endorsement as a mandatory property of therapy-impact claims. Canada has internationally respected traditions in randomized trials, clinical epidemiology, critical appraisal, systematic review, and evidence-based medicine. These emphasize empirical testing, bias, uncertainty, and reproducibility. Nevertheless, they do not necessarily require every HTA claim to be prospectively framed with an explicit empirical result that would demonstrate its failure. Sensitivity analysis, model validation, and scenario testing examine assumptions and outputs but are not substitutes for prospective evaluation, independent replication, and empirical falsification.

OVERALL INTERPRETATION

The Canadian curriculum profile is highly asymmetric. Directly observable outcomes are strongly recognized, and latent constructs receive somewhat greater recognition than in several other national knowledge bases. Almost every principle required to determine whether those outcomes and constructs have been lawfully measured, however, receives weak or minimal endorsement.

The lowest probabilities occur at the points where measurement science should constrain HTA practice: establishing measurement status before quantitative claims, the axioms of representational measurement, and the distinction between the ratio measurement requirements of manifest and latent attributes. Target-attribute specification, unidimensionality, and falsifiability are also weakly represented. These omissions deprive students of the intellectual framework needed to evaluate the measurement legitimacy of utilities, QALYs, cost-effectiveness ratios, and reference-case simulations.

The Canadian case is particularly significant because it represents curriculum construction rather than simple curriculum inheritance. Canadian academics and institutions contributed directly to the development of clinical epidemiology, health-utility research, pharmacoeconomics, outcomes measurement, and economic decision analysis. The curriculum did not merely adopt the contemporary HTA paradigm; Canadian scholarship helped create and legitimize it.

The result is an educational framework capable of producing substantial technical expertise while failing to provide the measurement competence needed to judge whether its principal methods support lawful quantitative claims. Students learn how to elicit preferences, estimate utility algorithms, calculate QALYs, construct cost-effectiveness models, and assess uncertainty before they learn how to establish that the quantities entering those operations are measures.

The failure is sequential. Ordinal responses to multidimensional health-state instruments are assigned preference values, entered into econometric models, converted into coefficients treated as utility weights, used to generate utility scores, multiplied by time to create QALYs, divided into costs to produce cost-per-QALY ratios, and propagated through simulation models. Multiplication and division require ratio measures, yet ratio measurement has not been established at the critical stages. Each inadmissible operation supplies the numerical input for the next.

Curriculum inversion therefore provides the educational mechanism through which measurement inversion is reproduced throughout Canadian HTA. The problem is not a collection of isolated methodological weaknesses. It is an integrated curriculum sequence that teaches the construction and manipulation of numbers before establishing whether those numbers are lawful measures.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF CANADIAN HTA

A central finding of the Canadian 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 Canadian 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, health-related quality of life, health-status measurement, utility assessment, 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 Canada this omission has particular significance. Canadian universities and research centres have played an influential role in the development of clinical epidemiology, evidence-based medicine, health-status measurement, patient-reported outcomes, health-utility systems, pharmacoeconomics, and economic evaluation. The Canadian HTA environment extends across university teaching, research centers, Canada's Drug Agency, provincial reimbursement and formulary systems, consultancy, and pharmaceutical-sector practice. These institutions do not merely apply contemporary HTA methods; Canadian academics have contributed directly to their development, refinement, and international dissemination. If the distinction between manifest and latent attributes is absent from the curriculum, the same omission is reproduced across research, utility assessment, reimbursement analysis, and professional decision making. Until this distinction becomes an organizing principle of Canadian HTA education, curriculum inversion will continue to reproduce measurement inversion throughout the Canadian HTA system.

THE ABSENCE OF RASCH IN CANADIAN HTA

The absence of the manifest-latent distinction also explains the marginal position of Rasch measurement within the Canadian HTA 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 Canada this omission is particularly significant. Canadian universities and research centers have played an internationally influential role in clinical epidemiology, health-status assessment, patient-reported outcomes, health-related quality of life, utility measurement, pharmacoeconomics, and economic evaluation. Canadian investigators contributed directly to the development and dissemination of multiattribute health-status and utility systems. The curriculum knowledge base has therefore not simply inherited the conventions of contemporary HTA; Canadian institutions have helped create, refine, and legitimize them. Yet this methodological development occurred without establishing the scientific foundations required for measurement of latent attributes. Curriculum inversion has consequently become embedded within teaching, research, and professional practice.

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 not embedded within the Canadian HTA curriculum knowledge base. Rasch methods may be encountered within specialist psychometrics, rehabilitation research, outcomes measurement, or instrument development, but they do not occupy the required foundational position within mainstream HTA education. Students and practitioners are introduced to patient-reported outcomes, utilities, multiattribute health-status 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, Canadian 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.

For Canada, the breadth and influence of its HTA knowledge base give this omission additional importance. Academic teaching, research centers, Canada's Drug Agency, provincial reimbursement systems, consultancy, professional practice, and the pharmaceutical sector are closely interconnected. Methods developed or legitimized within Canadian academia can be reproduced throughout the national assessment system and disseminated internationally. The absence of Rasch measurement is therefore not simply a gap in specialist psychometric teaching. It represents the absence from mainstream HTA of the measurement framework required to evaluate latent therapy outcomes. Until this gap is addressed, curriculum inversion will continue to sustain the broader pattern of measurement inversion identified within Canadian HTA.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN CANADA

The companion interrogation of the Canadian HTA knowledge base demonstrated that contemporary health technology assessment in Canada 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 this framework has been created, sustained, and transmitted across successive generations of practitioners. The answer is curriculum inversion.

The interrogation demonstrates that the Canadian 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 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 Canada, this conclusion has particular significance. Canadian universities and research centres have established internationally influential traditions in clinical epidemiology, evidence-based medicine, health economics, pharmacoeconomics, outcomes research, health-status assessment, and economic evaluation. Canadian investigators also contributed directly to the development and dissemination of multiattribute health-status systems and utility-based approaches to health assessment. Canada was therefore not simply a recipient of the contemporary HTA paradigm. Canadian institutions helped construct, refine, teach, and legitimize it.

The interrogation indicates, however, that this methodological development proceeded without embedding the principles of representational measurement. Curriculum inversion consequently became the mechanism through which measurement inversion was reproduced. Utilities, QALYs, cost-effectiveness ratios, and reference-case simulation models acquired professional legitimacy without first satisfying the requirements for lawful measurement. The Canadian contribution to contemporary HTA is therefore accompanied by a more uncomfortable conclusion: a technically sophisticated analytical framework was developed and disseminated without confronting the measurement requirements governing its constituent quantities and arithmetic operations.

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 or econometric 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 Canadian universities are therefore direct. Continuing to educate students in utility assessment, QALY construction, cost-effectiveness analysis, and reference-case modelling 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. Canada's Drug Agency, provincial reimbursement and formulary systems, university research centers, consultants, and the pharmaceutical sector depend upon practitioners trained to construct, review, and interpret economic evaluations and modelled claims. Curriculum inversion therefore supports a self-reinforcing methodological system. Universities teach the methods expected by assessment agencies; research centers refine and apply those methods; manufacturers and consultants construct submissions within the accepted framework; agencies assess those submissions according to the same methodological conventions; 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 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 Canadian HTA has reached its intellectual limit. It has undoubtedly contributed to evidence synthesis, structured reimbursement assessment, health-status research, 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 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.

Canada now faces a particularly important choice. A country that helped construct and legitimize the contemporary HTA paradigm can continue to reproduce measurement inversion through a curriculum that teaches arithmetic before measurement, or it can accept responsibility for helping to reconstruct HTA around the requirements of quantitative science. The future of Canadian HTA depends not upon further refinement of the paradigm Canada helped create, but upon replacing it with one founded on representational measurement, lawful quantitative inference, and prospectively evaluable, independently 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.

ACKNOWLEDGEMENT

I acknowledge that I have used OpenAI technologies, including the large language model, to assist in the development of this work. All final decisions, interpretations, and responsibilities for the content rest solely with me.

REFERENCES

[1] Canada: Academic research and the endorsement of measurement failure in health technology assessment. Logit Working Paper No 56. https://maimonresearch.com/logit-working-paper-no-56/

[2] Stevens S. On the Theory of Scales of Measurement. *Science*. 1946;103(2684):677-80

[3] Krantz D, Luce R, Suppes P, Tversky A. Foundations pf Measurement Vol 1: Additive and Polynomial Representations. New York: Academic Press, 1971

[4] Bond T, Zi Yan, Heene M. Applying the Rasch Model: Fundamental Measurement in the Human Sciences (4th Ed). New York Routledge, 2021

[5] Maimon Research. HTA Reconstruction. https://maimonresearch.com/hta-reconstruction-program-and-fees/