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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

BELGIUM: THE ENDORSEMENT OF CURRICULUM INVERSION

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ABSTRACT

A companion interrogation of the Belgian health technology assessment (HTA) knowledge base identified a consistent pattern of measurement inversion in which the requirements of representational measurement receive little recognition, while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and reference-case simulation are accepted as though they provide scientifically valid quantitative measures of therapy impact. The present study addresses the complementary question of whether this methodological failure is reproduced through the educational framework responsible for preparing successive generations of Belgian HTA practitioners.

A standardized large language model interrogation of the Belgian HTA curriculum knowledge base was undertaken using ten canonical statements derived from the requirements of representational measurement. These addressed target-attribute specification, scales of measurement, prior establishment of measurement status, the axioms of representational measurement, unidimensionality, manifest and latent attributes, their different requirements for ratio measurement, and falsifiability. Categorical endorsement probabilities and corresponding normalized logits were assigned to each statement.

The results demonstrate a consistent pattern of curriculum inversion. All ten canonical statements were located on the negative side of the logit continuum. The weakest endorsement concerned recognition that manifest and latent attributes require different forms of ratio measurement, with a probability of 0.05 and a normalized logit of −2.50. Measurement status and the axioms of representational measurement were similarly weakly endorsed. Although observable outcomes, scale terminology, and latent constructs receive limited recognition, these concepts are not integrated within a coherent measurement framework. Rasch measurement remains marginal and is not positioned as the required framework for estimating possession of latent attributes.

The Belgian findings are particularly significant because they arise within a mature, multidisciplinary HTA environment possessing substantial expertise in health economics, pharmacoeconomics, epidemiology, pharmacy, psychology, outcomes research, and quantitative analysis. Methodological sophistication has not resolved the measurement problem. Instead, the curriculum prepares practitioners to apply utilities, QALYs, economic evaluation, and decision modelling before establishing whether the quantities entering these operations are lawful measures.

The conclusion is curriculum inversion: measurement inversion is reproduced through education. Reconstruction requires HTA curricula to begin with the target attribute, distinguish manifest from latent attributes, apply linear ratio measurement to manifest attributes and Rasch logit ratio measurement to latent attributes, and require prospectively evaluable, independently replicable, and falsifiable therapy-impact claims. Measurement must precede arithmetic.

INTRODUCTION

The present analysis complements an earlier interrogation of the Belgian health technology assessment (HTA) knowledge base that examined the extent to which the accepted principles of representational measurement are recognized within contemporary [1] Belgian HTA. That investigation demonstrated a consistent pattern of measurement inversion across the national assessment environment, university-based health economics and pharmacoeconomic research, pharmacy and outcomes research, and the wider professional knowledge base supporting economic evaluation and healthcare decision making. 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 transmitted and sustained through the educational system responsible for preparing successive generations of Belgian HTA practitioners. It examines whether measurement inversion is accompanied by curriculum inversion.

The present analysis examines the Belgian 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 supporting Belgian HTA practice. 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 Belgian HTA education is grounded in the scientific conditions required for valid quantitative evaluation.

Belgium occupies an important position within European HTA. It combines an established national assessment infrastructure with major university centers in health economics, pharmacoeconomics, public health, epidemiology, clinical pharmacy, pharmaceutical care, evidence-based medicine, and outcomes research. The Belgian Health Care Knowledge Centre (KCE) provides a prominent institutional focus for health technology assessment and healthcare policy research, while the wider reimbursement and medicines environment creates continuing demand for economic evaluation, evidence assessment, and quantitative claims concerning therapy impact. Belgian universities and professional networks have consequently developed substantial methodological expertise in the techniques required to support healthcare assessment and decision making.

This institutional maturity makes Belgium particularly important for an interrogation of curriculum knowledge. Unlike a system required to adopt HTA rapidly in response to the creation of a new reimbursement architecture, Belgium has had the opportunity to develop a sophisticated and multidisciplinary methodological environment. Health economics, clinical epidemiology, pharmacy, medicine, psychology, statistics, and public health all contribute to the wider HTA knowledge base. The scientific resources required to question the measurement foundations of quantitative therapy assessment are therefore available. The critical issue is whether those resources have been brought together to establish measurement as the prior condition for arithmetic or whether the established European economic-evaluation paradigm has simply defined the terms of curriculum development.

The distinction is fundamental. A mature curriculum may become highly sophisticated in the application of accepted methods while leaving their scientific foundations unexamined. Students may be trained to select multiattribute instruments, estimate utilities, construct QALYs, undertake cost-effectiveness analyses, populate decision models, and characterize parameter uncertainty without first being required to establish the measurement status of the quantities entering these operations. Technical refinement does not resolve this omission. If utilities, QALYs, patient-reported outcome scores, and modelled therapy-impact claims are accepted as quantitative entities without prior demonstration that they satisfy the requirements of measurement, methodological sophistication merely embeds measurement failure more deeply within professional practice.

Belgium therefore presents a particularly revealing test of curriculum inversion. The question is not whether Belgian HTA education is technically advanced; there is little reason to doubt that it is. The question is whether technical competence is preceded by instruction in the scientific conditions required for quantitative claims. Are students first taught to specify the target attribute? Are they required to establish its measurement status? Do the properties of nominal, ordinal, interval, and ratio scales govern the permitted analysis? Are the axioms of representational measurement recognized? Is unidimensionality required before measurement? Are manifest and latent attributes distinguished, with recognition that they require different forms of ratio measurement? Are therapy-impact claims required to be empirically falsifiable?

If these principles receive consistently weak endorsement while utilities, QALYs, economic evaluation, and decision-analytic modelling remain dominant components of the educational framework, the result is curriculum inversion. In such a curriculum, arithmetic precedes measurement, analytical proficiency is developed before measurement competence, and methodological convention substitutes for prior scientific validation. The Belgian interrogation seeks to determine whether the educational framework supporting contemporary HTA satisfies the requirements of representational measurement or reproduces the same measurement inversion already identified within the Belgian 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 and measurement failure observed in current HTA practice.

The curriculum interrogations provide 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 BELGIAN HTA CURRICULUM KNOWLEDGE BASE

The Belgian HTA curriculum knowledge base is not located within a single degree, institution, or formally defined national curriculum. It is distributed across universities, government assessment structures, health economics and public health programs, pharmacy and pharmaceutical sciences, clinical epidemiology, evidence-based medicine, outcomes research, and professional training.

The relevant curriculum knowledge base is therefore best understood as the collective body of concepts, methodological assumptions, analytical techniques, and accepted practices through which future practitioners learn how therapies and health technologies should be assessed. It encompasses formal teaching but extends to research supervision, methodological guidance, published assessments, professional workshops, and the institutional expectations that define competence in contemporary HTA.

Belgium has a substantial academic infrastructure capable of supporting this knowledge base. Universities including KU Leuven, Ghent University, the University of Antwerp, UCLouvain, the Université libre de Bruxelles, Vrije Universiteit Brussel, and the University of Liège contribute expertise in health economics, pharmacy, public health, epidemiology, clinical research, and healthcare evaluation. Within these environments, students and researchers encounter economic evaluation, cost-effectiveness analysis, patient-reported outcomes, quality-of-life assessment, pharmaceutical care, evidence synthesis, health-services research, and quantitative methods. The Belgian Health Care Knowledge Centre provides a further institutional focus through its role in health technology assessment, healthcare research, and methodological evaluation. The curriculum knowledge base is consequently reinforced by close interaction between academic methods and the requirements of healthcare decision making.

The defining characteristic of this curriculum environment is its multidisciplinary sophistication. A practitioner may enter HTA from economics, pharmacy, medicine, epidemiology, statistics, psychology, or public health. Each discipline contributes a particular analytical language and set of techniques. Economists provide economic evaluation and modelling; epidemiologists provide comparative evidence and population methods; pharmacists contribute medicines evaluation and pharmaceutical care; outcomes researchers provide patient-reported instruments and quality-of-life assessments; and statisticians support estimation and uncertainty analysis. These competencies create a technically rich framework for assessing health technologies.

The difficulty is that multidisciplinarity does not itself provide a science of measurement. The contribution of multiple analytical disciplines may instead permit measurement assumptions to pass unchallenged between them. A patient-reported score may be accepted because it has been psychometrically validated. A utility value may be accepted because it is generated by an established preference-based instrument. A QALY may be accepted because it is required for cost-utility analysis. A modelled outcome may be accepted because it conforms to methodological guidance. At no point is one discipline necessarily responsible for asking whether the numerical quantity satisfies the axioms of representational measurement or supports the arithmetic subsequently applied.

The Belgian curriculum knowledge base is therefore shaped principally by the methods required to operate contemporary European HTA. Professional competence is demonstrated through familiarity with economic evaluation, utilities, QALYs, evidence synthesis, decision modelling, uncertainty analysis, and the interpretation of comparative outcomes. Measurement is generally implicit within these activities rather than established as a prior scientific task. The distinction between a numerical score and a measure, between manifest and latent attributes, and between ordinal observations and ratio quantities does not provide the organizing structure for curriculum development.

This is the context in which the present interrogation is undertaken. The issue is not whether Belgium possesses technical expertise in HTA; clearly it does. The issue is whether the collective educational knowledge base recognizes the scientific conditions that must be satisfied before quantitative claims of therapy impact are advanced. If representational measurement, target-attribute specification, unidimensionality, measurement status, ratio measurement, and falsifiability remain peripheral, then the curriculum reproduces the assumptions of the established HTA paradigm rather than subjecting them to scientific scrutiny. The consequence is curriculum inversion: practitioners are trained first in the manipulation of numerical claims and only, if at all, encounter the question of whether those numbers constitute measures.

INTERROGATING THE BELGIAN 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.

BELGIUM AND CURRICULUM INVERSION

The probability and logit profile presents a consistently negative assessment of the Belgian HTA curriculum knowledge base. (Table 1) The categorical probabilities represent the estimated likelihood that each canonical statement is endorsed, with the corresponding logits locating each statement on the interrogation continuum. The probabilities and logits are not additive and cannot be averaged. Their purpose is to display the relative position of each proposition and the overall pattern of endorsement across the ten canonical statements.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: BELGIAN KNOWLEDGE BASE

CANONICAL STATEMENT	CATEGORICAL PROBABILITY	NORMALIZED LOGIT
An attribute is the specific outcome of interest in a therapy assessment	0.30	-0.85
Every therapy assessment begins with specification of the target attribute	0.25	-1.10
The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis	0.25	-1.10
The measurement status of a target attribute must be established before quantitative claims can be advanced	0.10	-2.20
The axioms of representational measurement underpin quantitative claims	0.10	-2.20
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	0.40	-0.40
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	0.25	-1.10

The most striking feature is that all ten statements are located on the negative side of the logit continuum. No statement reaches a probability of 0.50. The highest assigned probability is 0.40, with a logit of −0.40, while the lowest is 0.05, with a logit of −2.50. The profile therefore provides no evidence that any of the canonical requirements of measurement is embedded as a dominant principle within the Belgian curriculum knowledge base. Even the most familiar propositions remain more likely to be absent or weakly endorsed than to function as accepted curriculum requirements.

There is also a clear movement toward increasingly negative logits as the statements approach the formal requirements of representational measurement. General recognition of outcomes, scale classifications and empirical observation occupies the less negative part of the continuum. By contrast, the requirement to establish measurement status before advancing quantitative claims, recognition of the axioms of representational measurement and the requirement for different forms of ratio measurement for manifest and latent attributes occupy strongly negative positions. The curriculum appears more comfortable with the language of outcomes and numerical analysis than with the scientific conditions required to establish measurement.

The profile is particularly important because it does not indicate a simple absence of technical or quantitative teaching. Belgian HTA is associated with sophisticated instruction in health economics, pharmacoeconomics, statistics, epidemiology, evidence synthesis and decision modelling. The negative logits instead point to a different problem: the principles of measurement are not positioned as prior requirements governing these analytical activities. Arithmetic and modelling can proceed without first demonstrating that the target attribute has been specified, that its measurement status has been established or that the numerical representation satisfies the requirements of the relevant scale.

The extreme negative location of the distinction between manifest and latent attributes and their different requirements for ratio measurement is especially revealing. This is not an isolated methodological detail but the point at which a measurement-based curriculum should divide its approach to therapy assessment. If the attribute is manifest, the task is to establish an appropriate linear ratio measure. If the attribute is latent, a measurement model is required to estimate possession of the attribute. The probability and logit profile indicates that this distinction is effectively absent from the organizing framework of Belgian HTA education.

Taken together, the categorical probability and logit locations demonstrate a coherent pattern of curriculum inversion. The principles that should precede quantitative analysis occupy negative positions throughout the continuum, while the established HTA framework proceeds directly to utilities, QALYs, economic evaluation and modelling. The Belgian curriculum knowledge base therefore appears structured around the application of accepted analytical methods rather than the prior establishment of lawful measurement. The statement-by-statement review that follows examines the specific dimensions of this failure.

STATEMENT-BY-STATEMENT REVIEW

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

Probability: 0.30 | Logit: −0.85

The Belgian HTA curriculum knowledge base provides limited recognition of the attribute as the specific object of measurement. Students encounter clinical outcomes, health states, patient-reported outcomes, quality of life, resource use, utilities and economic consequences, but these broad categories do not replace formal attribute specification. Teaching commonly begins with a technology, indication, comparator, reimbursement question or decision model rather than asking precisely what the therapy is intended to change. Instruments and analytical methods may therefore define the outcome instead of following from a previously specified attribute. The probability of 0.30 indicates that outcome identification is familiar, but the attribute is not consistently recognized as the prior empirical entity whose possession or magnitude must be established before any quantitative claim can be advanced.

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

Probability: 0.25 | Logit: −1.10

The Belgian HTA curriculum knowledge base provides weak endorsement of the requirement that every therapy assessment must begin with explicit specification of the target attribute. Students are more likely to be taught to formulate a decision problem through the population, intervention, comparator and outcome framework, or to begin with the evidentiary requirements of reimbursement and economic evaluation. These procedures may identify endpoints and outcome categories, but they do not necessarily establish a single target attribute. Broad constructs such as health-related quality of life, patient benefit, utility and wellbeing may be accepted without determining whether they represent one attribute, several attributes or a composite numerical construction. The probability of 0.25 indicates that target-attribute specification is not embedded as the mandatory first step governing the choice of instrument, unit, scale and analytical method.

3. The principal scales of measurement—nominal, ordinal, interval and ratio—have different properties and support different forms of analysis

Probability: 0.25 | Logit: −1.10

Belgian students are likely to encounter the four principal scales of measurement in introductory statistics, epidemiology, psychology or research-methods teaching. The curriculum knowledge base therefore has some awareness that nominal, ordinal, interval and ratio scales possess different properties. The weakness lies in the failure to carry these distinctions into HTA practice. Ordinal questionnaire responses, preference-based utility values, survival time, resource counts and monetary costs are routinely incorporated within the same analytical framework without requiring the arithmetic to conform to the properties of each scale. Scale classification is treated as descriptive background rather than as a binding constraint on quantitative operations. The probability of 0.25 therefore reflects familiarity with the terminology but limited recognition that the scale determines which comparisons, transformations and arithmetic procedures are scientifically admissible.

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

Probability: 0.10 | Logit: −2.20

The Belgian HTA curriculum knowledge base provides very weak recognition of the requirement that measurement status must be established before quantitative claims are advanced. Once an instrument, utility tariff, scoring system or modelling framework has been accepted within professional practice, the numerical output is generally treated as though measurement has already been achieved. Students are taught how to calculate scores, estimate utilities, construct QALYs and populate economic models without first being required to demonstrate that the target attribute possesses a lawful numerical representation. The distinction between generating a number and establishing a measure is therefore obscured. The probability of 0.10 and logit of −2.20 indicate that measurement does not consistently precede arithmetic. Instead, the analytical procedure itself is permitted to confer an assumed measurement status on the quantities it generates.

5. The axioms of representational measurement underpin quantitative claims

Probability: 0.10 | Logit: −2.20

The axioms of representational measurement occupy an almost invisible position within the Belgian HTA curriculum knowledge base. Students may receive advanced training in statistics, econometrics, epidemiology, decision analysis and evidence synthesis while remaining unfamiliar with the empirical conditions that justify numerical representation. Order, additivity, cancellation, solvability, invariance, the Archimedean condition and admissible transformations are not routinely presented as prerequisites for quantitative claims. Consequently, numerical assignments are accepted because they are generated by established instruments, algorithms or models rather than because the empirical relational structure has been shown to support the proposed scale. The probability of 0.10 demonstrates that Belgian HTA education is largely detached from the formal foundations of measurement. Quantitative sophistication therefore develops without the prior proof that the quantities being analysed satisfy the axioms required for lawful measurement.

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

Probability: 0.15 | Logit: −1.75

The Belgian HTA curriculum knowledge base provides weak recognition of unidimensionality as a necessary condition for measurement. The concept may be encountered in psychometrics, factor analysis, questionnaire development and specialist patient-reported outcome research, but it does not govern mainstream economic evaluation or utility assessment. Multiattribute health-status instruments intentionally combine mobility, self-care, usual activities, pain, anxiety and other qualitatively different attributes before producing a single numerical value. The resulting utility score is then treated as though it represents one measurable quantity. This practice indicates that dimensionality is considered a matter of statistical validation rather than a prior requirement for measurement. The probability of 0.15 and logit of −1.75 show that unidimensionality remains compartmentalized within specialist methods and is not enforced across the broader Belgian HTA curriculum.

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

Probability: 0.40 | Logit: −0.40

This statement receives the strongest endorsement within the Belgian curriculum profile because observable clinical and healthcare outcomes are central to medicine, pharmacy, epidemiology and HTA. Survival time, hospital admissions, treatment discontinuation, adverse events, medication use and healthcare-resource consumption can be directly recorded and evaluated. Belgian students are therefore likely to understand the empirical status of these outcomes. The limitation is that they are not consistently identified as manifest attributes with specific measurement requirements. Observable events may be counted or timed without a formal discussion of the conditions required for linear ratio measurement, unit definition, meaningful zero and admissible arithmetic. The probability of 0.40 nevertheless remains below neutral endorsement, indicating that direct observability is recognized more readily than the role of manifest attributes as one of the two foundational classes of measurement in therapy assessment.

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

Probability: 0.20 | Logit: −1.40

The Belgian HTA curriculum knowledge base provides weak recognition of the measurement requirements associated with latent attributes. Pain, fatigue, depression, physical functioning, treatment satisfaction and need fulfilment are likely to be understood as constructs that cannot be observed directly. However, the curriculum commonly treats validated questionnaires, summed scores, factor structures and preference algorithms as sufficient representations of these attributes. Students are not consistently required to distinguish between observing responses to items and estimating possession of the latent attribute itself. Nor are they required to use a measurement model that tests whether invariant measurement has been achieved. The probability of 0.20 and logit of −1.40 indicate that the latent character of many patient outcomes is partly recognized, but the necessity of a formal measurement model remains outside the organizing framework of mainstream Belgian HTA education.

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

Probability: 0.05 | Logit: −2.50

This statement occupies the most negative position in the Belgian interrogation. The curriculum knowledge base provides virtually no recognition that manifest and latent attributes require fundamentally different forms of ratio measurement. Manifest attributes require properly specified linear ratio measures, while latent attributes require Rasch logit ratio measures capable of estimating possession on an invariant continuum. Mainstream Belgian HTA does not appear to organize therapy assessment around this distinction. Rasch methods may be encountered in specialist psychometrics, rehabilitation or outcomes research, but they are not presented as the required solution to latent measurement. As a result, observable counts, summed ordinal scores, utilities and composite indices may all be treated as comparable numerical quantities. The probability of 0.05 and logit of −2.50 identify this omission as the central curriculum failure preventing a coherent measurement strategy for therapy impact.

10. Therapy impact claims must be falsifiable

Probability: 0.25 | Logit: −1.10

The Belgian HTA curriculum knowledge base provides limited recognition of falsifiability as a necessary property of therapy-impact claims. Students are likely to receive instruction in clinical trials, hypothesis testing, protocols, uncertainty analysis, evidence assessment and replication. These methods support empirical evaluation, but they do not necessarily require the final quantitative claim to be capable of falsification. Reference-case models commonly generate hypothetical lifetime QALYs, costs and cost-effectiveness ratios that cannot be directly observed or independently replicated as stated. Sensitivity and scenario analyses examine how model outputs respond to altered assumptions, but they do not test whether the claim corresponds to an observable empirical outcome. The probability of 0.25 therefore indicates that evaluative research is recognized, while the stronger requirement that each therapy-impact claim be framed so that it can be empirically challenged and potentially rejected remains weakly embedded.

OVERVIEW

The individual statement reviews demonstrate a consistent failure to embed the requirements of representational measurement within the Belgian HTA curriculum knowledge base. Limited recognition is given to observable outcomes, clinical endpoints, and the familiar terminology of measurement scales. However, this recognition does not translate into a coherent measurement framework for therapy assessment. The attribute is not established consistently as the specific object of measurement, and specification of the target attribute does not function as the mandatory first step in quantitative evaluation.

The weaknesses become more pronounced as the interrogation moves to the formal requirements of measurement. Measurement status is not required before quantitative claims are advanced, the axioms of representational measurement are largely absent, and unidimensionality is not enforced as a necessary condition for measurement. Although latent outcomes are familiar within patient-reported outcome and quality-of-life research, the distinction between observing item responses and estimating possession of a latent attribute remains poorly recognized.

Most importantly, the curriculum fails to distinguish the measurement requirements of manifest and latent attributes. Linear ratio measurement and Rasch logit ratio measurement do not provide the organizing framework for therapy assessment. Falsifiability is similarly weakly embedded. Taken together, the reviews identify curriculum inversion: accepted analytical methods precede measurement, allowing numerical outputs to be treated as quantitative claims without first establishing that lawful measurement has been achieved.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF BELGIAN HTA

A central finding of the Belgian 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 Belgian 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, utility assessment, clinical effectiveness, pharmaceutical care, health economics, 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 Belgium, this omission has particular significance. Belgium possesses a mature and multidisciplinary HTA environment supported by established expertise in health economics, pharmacoeconomics, epidemiology, public health, pharmacy, pharmaceutical care, evidence-based medicine, patient-reported outcomes, and healthcare evaluation. The national assessment environment and major university centers have had extensive opportunity to develop and refine the methodological foundations of therapy assessment. Belgium cannot readily be characterized as a system that simply adopted HTA rapidly in response to a newly created reimbursement structure. It is embedded within the European HTA mainstream and contributes substantial academic and methodological expertise to that environment.

This makes the absence of the manifest–latent distinction more consequential rather than less. The scientific disciplines required to recognize the distinction are present. Psychometrics recognizes latent constructs. Epidemiology and clinical research deal routinely with observable outcomes. Statistics distinguishes between data structures and permissible analytical operations. Health economics is concerned explicitly with quantitative comparison. Pharmacy and pharmaceutical care focus on therapy outcomes and medicines use. Yet these disciplinary contributions have not been integrated within a common representational measurement framework that begins by asking whether the target attribute is manifest or latent.

Instead, the established European economic-evaluation paradigm appears to provide the organizing architecture for Belgian HTA education. Utilities, QALYs, cost-effectiveness analysis, patient-reported outcome instruments, evidence synthesis, and decision modelling are taught as accepted methodological components of therapy assessment. Educational competence is consequently defined largely by the ability to understand, apply, and interpret these methods. The prior scientific question as to whether different classes of therapy outcome require fundamentally different forms of measurement remains outside the curriculum framework.

The Belgian case therefore illustrates how curriculum inversion can persist within a mature and technically sophisticated academic environment. The problem is not an absence of quantitative expertise. It is the failure to position measurement science above the individual analytical disciplines contributing to HTA. Each discipline supplies methods, instruments, scores, models, and numerical outputs, but no prior measurement framework determines whether these outputs constitute measures or whether the arithmetic applied to them is admissible.

If the distinction between manifest and latent attributes remains absent from Belgian HTA education, the same omission will continue to be reproduced across health economics, pharmacoeconomic research, pharmaceutical care, economic evaluation, outcomes research, healthcare assessment, and professional practice. Until this distinction becomes an organizing principle of Belgian HTA education, curriculum inversion will continue to sustain the measurement inversion embedded within the reference-case paradigm.

Belgium's challenge is therefore not simply to add a lecture on measurement theory to an otherwise unchanged curriculum. The curriculum must be reorganized around the nature of the target attribute and the form of lawful ratio measurement required to assess therapy impact. The first question in therapy assessment must become: what is the attribute? The second must be: is it manifest or latent? Only after these questions have been answered can the appropriate measurement framework be selected and quantitative claims legitimately advanced.

THE ABSENCE OF RASCH IN BELGIAN HTA

The absence of the manifest–latent distinction also explains the marginal position of Rasch measurement within the Belgian 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, pharmacoeconomics, health economic evaluation and reference-case modelling before they are taught to distinguish between manifest and latent attributes. Consequently, they are not encouraged to ask the fundamental scientific questions that should precede every HTA assessment: What is the target attribute? Is it manifest or latent? Which lawful form of ratio measurement is required?

For Belgium, this omission is particularly significant because HTA is embedded within a mature and multidisciplinary academic and assessment environment. Belgian universities and research institutions possess substantial expertise in health economics, pharmacoeconomics, pharmacy, psychology, epidemiology, public health, patient-reported outcomes and quantitative methods. The Belgian Health Care Knowledge Centre and the wider assessment and reimbursement environment have reinforced professional competence in economic evaluation, evidence synthesis and decision analysis. The intellectual resources required to identify the problem of latent attribute measurement are therefore present. Yet that problem has not acquired a foundational position within mainstream HTA education.

Belgium has developed as an established participant in the wider European HTA environment in which economic evaluation, cost-utility analysis, utility measurement, QALYs and model-based assessment possess substantial institutional legitimacy. Professional competence has consequently become associated with proficiency in utility assessment, QALY construction, cost-effectiveness analysis, sensitivity analysis and decision modelling. The prior question of whether patient-reported observations have been transformed into lawful measures of latent attribute possession remains outside the mainstream curriculum. Methodological maturity has refined the accepted analytical framework without requiring reconsideration of its measurement foundations.

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 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 Belgian HTA curriculum knowledge base. Rasch methods may be encountered within specialist psychometrics, psychology, 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, the Belgian HTA curriculum 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 Belgium, the maturity of the HTA environment gives this omission additional importance. University teaching, health-economic and pharmacoeconomic research, pharmaceutical care, outcomes research, assessment, consultancy and pharmaceutical-sector practice have developed around a common set of analytical expectations reinforced by the wider European HTA environment. Once these methods became embedded in professional practice, curricula naturally reproduced the competencies required by that system. The absence of Rasch measurement is therefore not simply a gap in specialist psychometric teaching. It represents the absence from mainstream Belgian HTA of the measurement framework required to evaluate latent therapy outcomes.

The Belgian case is particularly revealing because the relevant scientific expertise is already available. The problem cannot readily be attributed to a lack of quantitative sophistication, academic capacity or exposure to advanced methods. It reflects a failure to position the measurement of latent attributes as a prior scientific requirement for therapy assessment. Until Rasch measurement occupies this foundational position, curriculum inversion will continue to reproduce the broader pattern of measurement inversion identified within Belgian HTA.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN BELGIUM

The companion interrogation of the Belgian HTA knowledge base demonstrated that contemporary health technology assessment in Belgium is characterized by measurement inversion. The accepted principles of representational measurement receive little recognition, while utilities, quality-adjusted life years (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 is transmitted, sustained, and reproduced across successive generations of practitioners. The answer is curriculum inversion.

The interrogation demonstrates that the Belgian 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, health economics, pharmacoeconomics, economic evaluation, utilities, QALYs, decision modelling, evidence synthesis, patient-reported outcomes, pharmaceutical care, and healthcare 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 Belgium, this conclusion has particular significance. Belgian universities and research institutions possess substantial expertise in medicine, pharmacy, pharmaceutical care, public health, epidemiology, psychology, health economics, pharmacoeconomics, evidence-based medicine, patient-reported outcomes, and healthcare evaluation. The Belgian Health Care Knowledge Centre provides an established institutional focus for health technology assessment and methodological evaluation, while the wider assessment and reimbursement environment supports continuing demand for sophisticated quantitative analysis. Belgium is not a newcomer required to adopt an HTA framework rapidly in response to the creation of a new institutional system. It is a mature participant in the European HTA environment with extensive academic and methodological resources.

The persistence of curriculum inversion in this environment is therefore particularly difficult to defend. The scientific disciplines required to recognize the measurement problem are already present. Psychometrics addresses latent constructs. Statistics is concerned with the properties of data and permissible inference. Epidemiology distinguishes observations, outcomes, and study designs. Health economics depends upon quantitative comparison. Pharmacy and pharmaceutical care are concerned with therapy impact and medicines use. Yet these disciplines have not been integrated within a common framework of representational measurement. The result is a multidisciplinary HTA environment in which each discipline contributes methods and numerical outputs, but no prior measurement discipline determines whether those outputs constitute lawful measures.

The interrogation indicates that curriculum inversion has become the mechanism through which measurement inversion is reproduced. Utilities, QALYs, cost-effectiveness ratios, patient-reported outcome scores, and reference-case simulation models enter teaching and professional practice without first satisfying the requirements for lawful measurement. The maturity of the Belgian HTA environment has not corrected this failure. On the contrary, decades of methodological refinement have allowed the accepted analytical framework to become increasingly sophisticated while its measurement foundations remain unexamined. Technical development has institutionalized the paradigm rather than subjected it to first-principles scientific scrutiny.

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. The persistence of the problem despite extensive Belgian expertise demonstrates that the failure lies beneath the methodology itself, in the absence of lawful measurement.

The implications for Belgian 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. The Belgian assessment and reimbursement environment, KCE, university research groups, health economists, pharmacoeconomists, pharmacy and pharmaceutical-care researchers, consultants, and the pharmaceutical sector depend upon practitioners trained to construct, review, and interpret economic evaluations and modelled claims. Belgium's position within the wider European HTA environment further reinforces these methodological expectations. Curriculum inversion therefore supports a self-reinforcing system. Universities teach the methods required by assessment and reimbursement; researchers refine and apply those methods; manufacturers and consultants construct submissions within the accepted framework; assessment bodies review those submissions according to the same conventions; and

European methodological harmonization reinforces the professional competencies required. At no point is there a requirement to return to the prior scientific question: are the quantities being manipulated lawful measures?

The Belgian case is particularly revealing because the usual defence of methodological immaturity is unavailable. Belgium possesses the institutions, disciplines, academic expertise, and methodological experience required to identify the failure. The continued absence of representational measurement can therefore no longer be treated as a temporary stage in the evolution of HTA. It represents an established intellectual closure in which accepted methods define the boundaries of permissible methodological discussion. The paradigm is refined internally, but its measurement assumptions are not exposed to external scientific challenge.

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 Belgian HTA has reached its intellectual limit. It has undoubtedly contributed to the development of sophisticated economic evaluation, evidence synthesis, pharmaceutical assessment, and healthcare decision making, yet it has failed to establish the scientific legitimacy of the quantities upon which its quantitative claims depend. That framework has no scientific future because it rests upon measurement impossibilities. Its place is no longer at the centre of HTA education but in the history of the discipline as an instructive example of how methodological sophistication can develop independently of measurement science.

Belgium now faces a clear choice. It can continue to reproduce measurement inversion through a curriculum designed to supply practitioners proficient in the established European reference-case paradigm, or it can redefine professional competence around the requirements of quantitative science. The future of Belgian HTA depends not upon further refinement of an analytically sophisticated but measurement-deficient framework. It depends upon replacing that framework 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.

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