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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

PORTUGAL: THE ENDORSEMENT OF CURRICULUM INVERSION

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ABSTRACT

A companion interrogation of the Portuguese health technology assessment (HTA) knowledge base identified a consistent pattern of measurement inversion in which the principles of representational measurement receive little recognition while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and reference-case simulation are accepted as valid quantitative methods for assessing therapy impact. The present study examines the complementary question of whether this methodological failure is created and sustained through curriculum inversion within the educational knowledge base responsible for preparing Portuguese HTA practitioners.

A standardized large language model interrogation was applied to the Portuguese HTA curriculum knowledge base 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 corresponding ratio-measurement requirements, and falsifiability. Categorical probabilities and normalized logits were assigned to indicate the prominence of each concept within the curriculum knowledge base.

The results demonstrate pronounced curriculum inversion. Nine of the ten statements received probabilities of 0.20 or lower, while prior establishment of measurement status, representational measurement, and the different ratio-measurement requirements of manifest and latent attributes received the minimum probability of 0.05. Only recognition of directly observable manifest outcomes was strongly endorsed. The curriculum therefore emphasizes economic evaluation, utility assessment, QALYs, patient-reported outcomes, and decision modelling before establishing whether the quantities entering these analyses satisfy the requirements for lawful measurement.

Portugal represents an important case of European curriculum inheritance. A mature analytical framework based upon utilities, QALYs, cost-effectiveness ratios, and simulation modelling was available for adoption through European methodological guidance, textbooks, professional training, and assessment practice. Portugal consequently inherited not only the methods of contemporary HTA but the measurement failure embedded within them. Ordinal responses enter preference valuation and econometric models; estimated coefficients are treated as utility weights; utilities are multiplied by time to create QALYs; and costs are divided by QALYs despite the absence of required ratio measurement.

The findings indicate that reconstruction of Portuguese HTA must begin with curriculum transformation. Target attributes must be specified, manifest and latent attributes distinguished, and linear ratio and Rasch logit ratio measurement applied as appropriate. Measurement must precede arithmetic. Without this transformation, curriculum inversion will continue to reproduce measurement inversion throughout Portuguese HTA education, research, reimbursement assessment, and professional practice.

INTRODUCTION

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

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

Portugal occupies an important position within the development of European HTA. Its national assessment and reimbursement framework has evolved within a wider European environment in which economic evaluation, utilities, QALYs, cost-effectiveness analysis, and model-based decision making were already established methodological conventions. Portuguese universities and research groups have developed expertise in pharmacy, medicine, public health, epidemiology, health economics, outcomes research, economic evaluation, and health-policy assessment. At the same time, participation in the wider European HTA environment has encouraged methodological harmonization and the adoption of common approaches to evidence assessment and economic evaluation. The Portuguese curriculum knowledge base has therefore developed through a combination of domestic professional education and the inheritance of an established European analytical framework.

This history is important because Portugal did not need to construct contemporary HTA methodology from first principles. The dominant economic-evaluation paradigm was already available, supported by European methodological guidance, international textbooks, professional training, and established assessment practice. The critical question is whether the scientific

foundations of measurement were examined before this analytical architecture was incorporated into Portuguese teaching and professional formation. If utilities, QALYs, cost-effectiveness methods, patient-reported outcomes, and decision models were introduced as accepted quantitative methods without first establishing the measurement status of their constituent quantities, Portugal inherited not only the methods of contemporary HTA but also their measurement failure.

The central question addressed by this interrogation is therefore whether Portuguese HTA education introduces students and practitioners first to the scientific principles governing measurement before presenting the accepted analytical methods of contemporary HTA. If target-attribute specification, scale properties, representational measurement, unidimensionality, manifest and latent attributes, ratio measurement, and falsifiability 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, technical proficiency is developed before scientific competence, and methodological convention substitutes for prior measurement validation. The Portuguese 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 Portuguese 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 PORTUGUESE HTA CURRICULUM KNOWLEDGE BASE

The Portuguese health technology assessment (HTA) curriculum knowledge base is distributed across universities, professional education, research groups, national assessment activities, and the wider European methodological environment. Portugal does not possess a single nationally prescribed educational pathway through which all HTA practitioners are trained. Instead, the knowledge and competencies associated with HTA are acquired through pharmacy, medicine, public health, epidemiology, health economics, outcomes research, economic evaluation, and health-policy education. These different educational pathways collectively create the professional knowledge base supporting contemporary Portuguese HTA.

Universities occupy a central position within this framework. Relevant teaching is located across faculties of pharmacy and medicine, schools of public health, economics and management programs, and postgraduate research training. Students may encounter economic evaluation through pharmacoeconomics, health economics, health-services research, clinical research, epidemiology, or pharmaceutical policy. Specialist postgraduate and professional training further reinforces these methods. The resulting curriculum is institutionally dispersed but connected by a broadly common understanding of the analytical methods expected within contemporary HTA.

The dominant curriculum emphasis is upon clinical evidence, comparative effectiveness, economic evaluation, cost-effectiveness and cost-utility analysis, utility assessment, QALYs, patient-reported outcomes, decision trees, Markov models, sensitivity analysis, and uncertainty.

These methods provide the technical competencies required to construct, interpret, and review economic assessments of medicines and other health technologies. They also reflect the analytical conventions embedded within national reimbursement and assessment practice and the wider European HTA environment.

Portugal's position within Europe is particularly important in shaping this curriculum knowledge base. Contemporary Portuguese HTA developed within an international environment in which the principal architecture of economic evaluation had already been established. Utilities, QALYs, incremental cost-effectiveness ratios, and model-based assessment were presented through textbooks, methodological guidance, professional training, and European cooperation as accepted components of HTA. Portuguese educators and practitioners therefore did not need to develop an independent analytical paradigm. The existing framework could be adopted, adapted to national requirements, and incorporated into professional education.

This inheritance has an important consequence. The curriculum is directed primarily toward competence in applying accepted methods rather than evaluating their measurement foundations. Students learn how utilities are elicited, how QALYs are calculated, how cost-effectiveness ratios are constructed, and how decision models are populated and subjected to sensitivity analysis. There is little indication that these methods are preceded by systematic teaching in representational measurement, the arithmetic restrictions imposed by scales of measurement, admissible transformations, dimensional homogeneity, or the axioms required for lawful quantitative claims.

The distinction between manifest and latent attributes is similarly absent as an organizing principle. Survival, hospital admissions, adverse events, medication use, and resource utilization are recognized as observable outcomes. Pain, fatigue, functioning, anxiety, treatment satisfaction, and quality of life are addressed through patient-reported instruments and health-status systems. Yet these two classes of attribute are not systematically separated according to their different measurement requirements. The corresponding distinction between linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes therefore remains outside the mainstream curriculum.

Rasch measurement may be encountered within specialist psychometric, rehabilitation, psychology, or instrument-development activities, but it does not occupy a foundational position within Portuguese HTA education. Students can consequently become proficient in patient-reported outcomes, utility algorithms, QALY construction, and economic modelling without first being required to demonstrate that a latent attribute has been measured.

The Portuguese HTA curriculum knowledge base is therefore technically competent but scientifically inverted. Its weakness is not a shortage of analytical methods. It lies in the sequence through which those methods are taught. The established European HTA framework is introduced before the measurement principles required to evaluate it. Students learn to manipulate numerical values before establishing whether those values are lawful measures. Portugal has consequently inherited not only the methods of contemporary European HTA but the curriculum inversion through which measurement inversion is sustained.

INTERROGATING THE PORTUGUESE 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.

PORTUGAL AND CURRICULUM INVERSION

The Portuguese HTA curriculum knowledge base demonstrates a pronounced pattern of curriculum inversion (Table 1). Nine of the ten canonical statements receive probabilities of 0.20 or lower. Six receive probabilities of 0.10 or lower, while the three statements most directly concerned with the scientific foundations of measurement receive the minimum probability of 0.05. The profile indicates that Portuguese students and practitioners are more likely to encounter the accepted methods of economic evaluation and evidence assessment than the principles required to establish whether the quantities entering those methods are lawful measures.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: PORTUGUESE KNOWLEDGE BASE

CANONICAL STATEMENT	CATEGORICAL PROBABILITY	NORMALIZED LOGIT
An attribute is the specific outcome of interest in a therapy assessment	0.15	-1.75
Every therapy assessment begins with specification of the target attribute	0.10	-2.20
The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis	0.20	-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	0.10	-2.20
A manifest attribute is directly observable and capable of supporting empirical observation	0.80	+1.40
A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute	0.20	-1.40
Manifest and latent attributes require different forms of ratio measurement	0.05	-2.50
Therapy impact claims must be falsifiable	0.10	-2.20

The only strongly endorsed statement is the recognition of manifest attributes as directly observable. This reflects the foundations of clinical medicine, pharmacy, epidemiology, public health, and health-services research. Survival, admissions, emergency visits, adverse events, laboratory results, treatment discontinuation, medication use, and resource utilization are readily recognized as empirical outcomes. The limitation is that they are not generally classified as manifest attributes within a representational-measurement framework or linked explicitly to the requirements of linear ratio measurement.

Recognition of the attribute and target attribute is weak. Portuguese HTA education appears more likely to begin with a technology, clinical problem, comparator, outcome set, economic question, or reimbursement decision than with explicit specification of the single attribute intended to be measured. Outcomes may be selected for inclusion in an assessment without being defined independently of the instrument, utility system, or analytical model used to represent them.

The principal scales of measurement receive slightly greater recognition, reflected in a probability of 0.20. Nominal, ordinal, interval, and ratio scales are likely to appear within statistics, epidemiology, psychology, and research-methods education. Portugal's university sector provides both theoretically oriented and professionally oriented quantitative training. However, familiarity with scale terminology does not mean that its restrictions are carried forward into HTA. There is

little indication that students are routinely required to establish whether utility values, patient-reported scores, QALYs, or model outputs support multiplication, division, ratios, or percentage change.

The minimum probability assigned to prior establishment of measurement status identifies the central inversion. Numerical outcomes, preference values, utility scores, and model parameters are accepted as analytical inputs without first demonstrating that they possess the properties required for the arithmetic proposed. The existence of a numerical value is effectively allowed to substitute for proof of measurement.

Representational measurement is similarly absent as an organizing curriculum framework. Order, additivity, solvability, cancellation, invariance, admissible transformations, and dimensional homogeneity do not appear to provide the scientific foundation for HTA teaching. Instead, students encounter the familiar international architecture of clinical evidence, economic evaluation, cost-effectiveness, cost-utility analysis, and modelling. HTA internationally is commonly framed around clinical effectiveness, safety, cost-effectiveness, and decision support, which helps explain the methods likely to dominate national teaching.

Unidimensionality receives weak endorsement. It may be recognized within specialist psychometric or questionnaire-development work, but it does not appear to function as a universal prerequisite for measurement. Multidimensional health descriptions can therefore be combined, valued, and represented through a single score without first demonstrating that one attribute is being measured.

The latent-attribute statement receives a probability of 0.20. Portuguese curricula in psychology, clinical research, pharmacy, and outcomes assessment are likely to recognize that pain, fatigue, functioning, anxiety, satisfaction, and quality of life cannot be observed in the same manner as survival or hospital use. Yet recognition that an outcome is indirectly observed is not equivalent to recognizing that possession of the attribute requires a measurement model satisfying the axioms of measurement.

The distinction between the measurement requirements of manifest and latent attributes receives the minimum probability. There is little evidence that Portuguese HTA education is organized around linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes. Observable outcomes, questionnaire scores, utility values, preference weights, and modelled outcomes are instead brought into a common analytical framework despite possessing fundamentally different measurement properties.

Falsifiability also receives weak endorsement. Portuguese teaching in clinical and public-health research will emphasize study design, evidence, uncertainty, bias, and statistical testing. These are important scientific practices, but they are not equivalent to requiring that every therapy-impact claim be framed prospectively with explicit conditions under which it would be rejected. Sensitivity analysis and scenario testing examine models; they do not make the underlying claim empirically falsifiable.

OVERALL ASSESSMENT

Portugal appears to represent a case of European curriculum inheritance reinforced through national professional application. Its HTA curriculum knowledge base has developed within a mature European environment in which utilities, QALYs, economic evaluation, and model-based decision making were already established as accepted methods. The analytical architecture was therefore available for adoption before Portuguese curricula had any reason to construct an independent foundation in representational measurement.

The result is not a lack of technical sophistication. Portuguese universities provide substantial education in pharmacy, medicine, economics, statistics, clinical research, and public health. The problem lies in the sequence through which competence is developed. Students are introduced to instruments, utility values, cost-effectiveness methods, and decision models before being required to establish the measurement status of the quantities being manipulated.

The failure is sequential. Ordinal health-state responses enter preference-valuation exercises and econometric models; estimated coefficients are treated as utility weights; utilities are multiplied by time to generate QALYs; costs are divided by QALYs; and the resulting numerical constructions are propagated through simulation models. Multiplication and division require ratio measures, yet ratio measurement has not been demonstrated at the critical stages.

The Portuguese curriculum knowledge base therefore exhibits curriculum inversion. It teaches the accepted arithmetic and modelling of HTA before establishing the conditions required for lawful measurement. In this respect, Portugal appears to have inherited not only the contemporary European HTA framework but also the measurement failure embedded within it.

STATEMENT-BY-STATEMENT REVIEW

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

Probability: 0.15 | Logit: −1.75

The Portuguese HTA curriculum knowledge base provides weak recognition of the attribute as the specific object of measurement. Students encounter clinical outcomes, health states, patient-reported outcomes, quality of life, resource use, and economic consequences, but these categories do not replace formal attribute specification. Teaching commonly begins with a technology, comparator, decision problem, or model rather than asking what precisely the therapy is intended to change. Instruments and analytical methods may therefore define the outcome instead of following from a previously specified attribute. The low probability reflects the absence of attribute specification as the organizing starting point for quantitative assessment.

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

Probability: 0.10 | Logit: −2.20

There is little evidence that Portuguese HTA education requires target-attribute specification as the mandatory first step in therapy assessment. Curricula typically emphasize populations, interventions, comparators, outcomes, evidence, perspectives, and model structures. These are important, but they do not identify the particular attribute whose change is being claimed. Without prior specification, there is no coherent basis for selecting a measurement method or judging whether the resulting numerical values represent the intended outcome. The strongly negative logit indicates that the analytical framework generally precedes formal definition of the object of measurement.

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

Probability: 0.20 | Logit: −1.40

Nominal, ordinal, interval, and ratio scales are likely to appear in Portuguese statistics, epidemiology, psychology, and research-methods courses. There is little evidence, however, that their arithmetic implications are systematically applied within HTA. Students may learn the terminology without being required to determine whether utility values, questionnaire scores, QALYs, or model outputs support multiplication, division, ratios, or percentage change. Scale classification is therefore separated from analytical practice. The probability of 0.20 reflects limited awareness but weak enforcement of the restrictions imposed by different measurement scales.

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

Probability: 0.05 | Logit: −2.50

This statement receives minimal endorsement within the Portuguese curriculum knowledge base. Questionnaire scores, preference values, utilities, and model parameters are treated as quantitative inputs without first demonstrating that they are measures. Their numerical form effectively becomes sufficient authority for arithmetic and modelling. The essential distinction between a number and a measure is consequently obscured. Students learn how numerical values are combined and interpreted before establishing whether those values possess the properties required for the proposed operations. This is one of the clearest expressions of curriculum inversion.

5. The axioms of representational measurement underpin quantitative claims

Probability: 0.05 | Logit: −2.50

Representational measurement is effectively absent as an organizing framework for Portuguese HTA education. Order, additivity, solvability, cancellation, invariance, admissible

transformations, and dimensional homogeneity do not appear to govern the construction of quantitative claims. Students are introduced directly to utility assessment, QALYs, cost-effectiveness analysis, and decision modelling as established methods. Without the axiomatic framework, they lack the scientific criteria required to distinguish lawful measurement from numerical construction. The minimum probability therefore represents a foundational curriculum failure rather than the omission of an optional specialist topic.

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

Probability: 0.10 | Logit: −2.20

Unidimensionality receives little recognition as a universal prerequisite for measurement. It may appear within specialist psychometric, factor-analytic, or questionnaire-development teaching, but it does not appear to govern mainstream Portuguese HTA education. Multiattribute health instruments combine mobility, pain, anxiety, self-care, and other domains into a single score or utility without first demonstrating that one attribute is being measured. Numerical aggregation is consequently allowed to substitute for a unidimensional measurement structure. The low probability reflects the marginal position of this essential requirement.

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

Probability: 0.80 | Logit: +1.40

This is the only strongly endorsed statement. Portuguese medicine, pharmacy, epidemiology, and public-health education clearly recognize outcomes that can be counted, timed, or directly recorded. These include survival, hospital admissions, emergency visits, adverse events, treatment discontinuation, laboratory results, and resource utilization. The limitation is that such outcomes 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. Recognition of empirical outcomes therefore exceeds recognition of their measurement implications.

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

Portuguese curricula recognize that pain, fatigue, anxiety, functioning, satisfaction, and quality of life require indirect assessment through patient responses. What is largely absent is the stronger requirement that possession of these latent attributes must be estimated through a measurement model satisfying the conditions for lawful measurement. Ordinal questionnaire responses are commonly converted into summed scores, composite indices, or utilities without first demonstrating that the underlying attribute has been measured. The probability of 0.20 therefore

reflects awareness of indirect observation but limited recognition of the measurement problem it creates.

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

Probability: 0.05 | 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 Portuguese curriculum knowledge base. Observable outcomes, questionnaire scores, preference weights, utility values, and modelled quantities are incorporated into a common analytical framework despite possessing fundamentally different measurement properties. Teaching does not appear to begin by classifying the target attribute and identifying the appropriate form of ratio measurement. The minimum probability identifies a structural failure: Portuguese HTA lacks a coherent measurement strategy connecting attribute type to lawful quantitative assessment.

10. Therapy-impact claims must be falsifiable

Probability: 0.10 | Logit: −2.20

Falsifiability receives weak recognition as a mandatory property of therapy-impact claims. Portuguese clinical and public-health education emphasizes study design, evidence, uncertainty, bias, and statistical testing, but these do not necessarily require a claim to specify in advance the empirical result that would demonstrate its failure. Sensitivity and scenario analyses test the behavior of models under changing assumptions rather than exposing therapy-impact claims to direct empirical rejection. The low probability reflects an educational environment in which uncertainty management is emphasized more strongly than prospective evaluation, independent replication, and falsification.

OVERVIEW

The Portuguese interrogation demonstrates a strongly asymmetric curriculum knowledge base. Directly observable outcomes are readily recognized, but nearly all principles required to convert observations into lawful quantitative claims receive weak or minimal endorsement. The lowest probabilities occur for prior establishment of measurement status, representational measurement, and the different ratio-measurement requirements of manifest and latent attributes. Portuguese students can therefore acquire technical proficiency in utilities, QALYs, economic evaluation, and decision modelling without first acquiring the measurement competence required to evaluate those methods. This is curriculum inversion: arithmetic and modelling precede measurement.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF PORTUGUESE HTA

A central finding of the Portuguese 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 Portuguese 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, 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 Portugal this omission has particular significance. Portuguese HTA education and professional practice have developed within the wider European framework of economic evaluation, cost-utility analysis, utility assessment, QALYs, and model-based decision making. Universities, research groups, national assessment and reimbursement activities, consultancy, and pharmaceutical-sector practice have adopted and adapted methods already established within European and international HTA. The Portuguese curriculum knowledge base has therefore inherited an analytical framework in which the distinction between manifest and latent attributes was never established as a foundational measurement principle. If that distinction remains absent from education, the same omission will continue to be reproduced across research, economic evaluation, reimbursement assessment, and professional practice. Until manifest and latent attributes become an organizing principle of Portuguese HTA education, curriculum inversion will continue to reproduce the measurement inversion embedded within the wider European HTA framework.

THE ABSENCE OF RASCH IN PORTUGUESE HTA

The absence of the manifest-latent distinction also explains the marginal position of Rasch measurement within the Portuguese 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 Portugal this omission is particularly significant because Portuguese HTA education has developed within the wider European framework of health economics, economic evaluation, cost-utility analysis, utility measurement, and model-based assessment. Portuguese universities and research groups have developed substantial expertise in pharmacy, medicine, public health, epidemiology, health economics, outcomes research, and economic evaluation. The curriculum knowledge base has, however, largely inherited an international analytical framework in which utilities, QALYs, and reference-case modelling were already accepted as established methods. The scientific problem of latent attribute measurement was therefore never required to occupy a foundational position. Portugal inherited not only the methods of contemporary European HTA but the measurement assumptions embedded within them.

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 Portuguese 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, Portuguese HTA proceeds as though this distinction does not exist. Students consequently learn how utilities are generated, how QALYs are constructed, and how economic models are populated, yet they are not taught how latent attributes themselves can be measured. The curriculum therefore introduces numerical representations of patient benefit before introducing the scientific framework required to justify those representations. This is curriculum inversion in its clearest form.

For Portugal, its position within the wider European HTA environment gives this omission additional importance. University teaching, national assessment and reimbursement activities, health economics research, consultancy, professional practice, and the pharmaceutical sector operate within a methodological framework increasingly shaped by European cooperation and harmonization. Analytical conventions accepted within the wider European HTA system are readily reproduced within Portuguese education and practice. The absence of Rasch measurement is therefore not simply a gap in specialist psychometric teaching. It represents the absence from mainstream Portuguese 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 Portuguese HTA.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN PORTUGAL

The companion interrogation of the Portuguese HTA knowledge base demonstrated that contemporary health technology assessment in Portugal 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 is transmitted, sustained, and reproduced across successive generations of practitioners. The answer is curriculum inversion.

The interrogation demonstrates that the Portuguese 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 Portugal, this conclusion has particular significance. Portuguese universities and research groups have developed substantial expertise in pharmacy, medicine, public health, epidemiology, health economics, outcomes research, economic evaluation, and health-policy assessment. Contemporary Portuguese HTA has, however, evolved within a wider European methodological environment in which utilities, QALYs, cost-effectiveness analysis, and model-based decision making were already established as accepted components of technology assessment. Portugal was therefore not required to construct the contemporary HTA paradigm from first principles. It inherited an analytical architecture already legitimized through European and international methodological guidance, textbooks, professional training, and assessment practice.

The interrogation indicates that this inheritance occurred 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 entered teaching and professional practice without first satisfying the requirements for lawful measurement. Portugal therefore inherited not only the analytical methods of contemporary European HTA but also the measurement failure embedded within them. A technically sophisticated framework was adopted and applied 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 Portuguese 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 Portuguese national assessment and reimbursement environment, university research groups, health economists, consultants, and the pharmaceutical sector depend upon practitioners trained to construct, review, and interpret economic evaluations and modelled claims. Portugal's participation in the wider European HTA environment further reinforces these methodological expectations. Curriculum inversion therefore supports a self-reinforcing system. Universities teach the methods expected in assessment and reimbursement; researchers refine and apply those methods; manufacturers and consultants construct analyses within the accepted framework; assessment bodies review those analyses according to the same conventions; and European methodological harmonization further 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 Portuguese HTA has reached its intellectual limit. It has undoubtedly contributed to evidence synthesis, structured reimbursement assessment, economic evaluation, and administrative decision making, yet it has failed to establish the scientific legitimacy of the quantities upon which its quantitative claims depend. That framework has no scientific future because it rests upon measurement impossibilities. Its place is no longer at the centre of HTA education but in the history of the discipline as an instructive example of how methodological sophistication can evolve independently of measurement science.

Portugal now faces a clear choice. It can continue to reproduce measurement inversion through a curriculum that teaches arithmetic before measurement and perpetuates the assumptions of an inherited European paradigm, or it can reconstruct HTA around the requirements of quantitative science. The future of Portuguese HTA depends not upon further refinement of the framework it inherited 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.

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