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REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

AUSTRIA: CURRICULUM INVERSION IN HEALTH TECHNOLOGY ASSESSMENT

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

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ABSTRACT

The document argues that Austrian HTA is characterized by curriculum inversion: the methods of the reference-case paradigm are taught before the scientific principles required to determine whether those methods can support lawful quantitative claims. Drawing upon a large language model interrogation of the Austrian curriculum knowledge base, the study evaluates the extent to which the educational foundations of HTA recognize the concepts required by representational measurement. These include specification of the target attribute, the principal scales of measurement, admissible arithmetic, representational measurement, unidimensionality, the distinction between manifest and latent attributes, lawful ratio measurement, Rasch measurement for latent constructs, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification.

The interrogation employs ten canonical statements representing the minimum scientific foundations expected in a curriculum committed to quantitative assessment. Across all statements, endorsement is consistently weak. The Austrian curriculum knowledge base gives priority to evidence synthesis, comparative effectiveness, health economic evaluation, utilities, QALYs, decision modelling, and reimbursement methodology while providing little recognition of the measurement principles upon which those methods depend. The findings closely parallel those of the companion interrogation of the Austrian methodological knowledge base, where measurement inversion was shown to characterize HTA practice. Together, the two studies demonstrate that curriculum inversion provides the educational mechanism through which measurement inversion is reproduced across successive generations of researchers, practitioners, consultants, and policy advisers.

The paper argues that this omission is not a minor curricular deficiency but a fundamental scientific failure. Without lawful measurement, arithmetic cannot generate valid quantitative claims, regardless of the sophistication of the statistical or simulation methods employed. Utilities, QALYs, and reference-case models therefore remain numerical constructions rather than scientifically defensible measures of therapy impact. Teaching these methods without first establishing the standards of representational measurement leaves students technically proficient in analytical procedures while lacking the conceptual framework necessary to evaluate their scientific legitimacy.

The study concludes that Austrian HTA requires educational reconstruction rather than incremental methodological refinement. A measurement-based curriculum should begin with attributes, representational measurement, scale theory, unidimensionality, the distinction between manifest and latent attributes, and the application of linear ratio and Rasch logit ratio measurement before introducing economic evaluation and decision modelling. Austria possesses the academic expertise to lead this transition. By restoring measurement to its proper place as the foundation of quantitative science, Austrian universities and HTA institutions can strengthen both the scientific integrity of national HTA and their contribution to the future development of measurement-based health technology assessment throughout Europe.

INTRODUCTION

A large language model interrogation of the Austrian health technology assessment knowledge base has demonstrated strong endorsement of measurement inversion [1]. Across HTA agencies, academic research groups, public health institutes, university teaching, professional training, and methodological publications, the same pattern emerges: the scientific principles required for lawful quantitative measurement receive little recognition, while utilities, QALYs, cost-effectiveness analysis, and decision-analytic modelling are treated as though they provide scientifically valid measures of therapy impact. These findings indicate that measurement inversion is not confined to a particular institution or program but characterizes the Austrian HTA knowledge base as a whole.

The present paper addresses the complementary question of whether this pattern of measurement inversion is accompanied by curriculum inversion. This is a critical issue because HTA practice is not reproduced spontaneously. It is reproduced through education, professional training, doctoral supervision, methodological guidance, workshops, agency procedures, and the wider academic literature. If students and practitioners are introduced to the techniques of HTA before they are introduced to the scientific standards required to evaluate those techniques, then curriculum inversion becomes the mechanism through which measurement inversion is sustained.

Austria provides an important case for this interrogation. The Austrian Institute for Health Technology Assessment, UMIT Tirol, the Medical University of Vienna, the Institute for Advanced Studies, the Austrian National Public Health Institute, and associated university and policy networks together constitute a sophisticated HTA and health economics environment. Austria is not methodologically isolated. Its HTA community is closely linked to European assessment traditions, evidence-based medicine, decision analysis, health economics, EUnetHTA experience, and the emerging European Union HTA framework. For that reason, the Austrian curriculum knowledge base is not merely a national concern. It is part of the wider European educational environment through which contemporary HTA methods are transmitted and legitimized.

The purpose of the present interrogation is to determine whether the Austrian HTA curriculum knowledge base introduces students and practitioners to the scientific foundations of measurement before presenting the established methods of contemporary HTA. In particular, the interrogation asks whether curricula and training materials begin with specification of the target attribute, the principal scales of measurement, the axioms of representational measurement, unidimensionality, the distinction between manifest and latent attributes, lawful ratio measurement, Rasch measurement for latent constructs, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification.

The results demonstrate a consistent pattern of curriculum inversion. Across the ten canonical statements, the foundational concepts required for quantitative science receive uniformly weak endorsement. By contrast, the curriculum knowledge base emphasizes evidence synthesis, comparative effectiveness, health economic evaluation, utilities, QALYs, modelling, reimbursement relevance, and policy support. Students and practitioners are therefore taught how to apply the accepted procedures of HTA before they are taught the measurement standards required to determine whether those procedures can support lawful quantitative claims.

These findings closely parallel those of the companion paper on measurement inversion. There, the Austrian HTA methodological knowledge base was shown to endorse analytical methods that fail the accepted standards of representational measurement. Here, the educational knowledge base is shown to reproduce those same assumptions by transmitting methodological practice without first establishing its scientific foundations. Curriculum inversion therefore emerges as the educational mechanism through which measurement inversion is institutionalized and perpetuated within Austrian health technology assessment.

STANDARDS FOR MEASUREMENT

The starting point for any scientific discipline that seeks to make quantitative claims is measurement. Before quantities can be manipulated mathematically, it must first be demonstrated that they possess the properties necessary to support the proposed arithmetic operations. This principle is fundamental to both the physical and social sciences. Measurement precedes arithmetic. Quantitative claims are valid only when the quantities involved satisfy the requirements of measurement. If these requirements are absent, arithmetic operations may still be performed, but the resulting outputs have no scientific standing as measures.

The importance of this principle is reflected in the theory of measurement scales [2]. Not all numerical assignments possess the same properties. Nominal scales classify. Ordinal scales rank. Interval scales support differences between values. Ratio scales alone support the full range of arithmetic operations because they possess a true zero and permit proportional comparisons. Consequently, the admissibility of arithmetic depends upon scale type. Addition and subtraction require at least interval properties. Multiplication and division require ratio properties. This is not a matter of convention. It is a requirement imposed by the structure of measurement itself.

The central importance of ratio measurement follows directly from these considerations. Any claim involving multiplication, division, proportional comparison, growth rates, averages of ratios, or cost-effectiveness ratios requires quantities that possess ratio properties. If ratio measurement has not been demonstrated, these operations are inadmissible. Numerical manipulation cannot create measurement properties that are absent from the underlying scale. Arithmetic cannot substitute for measurement.

These requirements are formalized in the axioms of representational measurement [3]. Representational measurement provides the scientific framework that links empirical observations to numerical representations. Its purpose is to ensure that numerical assignments preserve the structure of the attribute being measured. Only when this correspondence is demonstrated can arithmetic operations be regarded as meaningful. The axioms of representational measurement therefore establish the conditions under which quantitative claims can be considered scientifically legitimate.

Among the most important of these requirements is unidimensionality. Measurement requires that an attribute represent a single dimension. If multiple attributes are combined into a composite score, numerical aggregation may be possible, but measurement has not necessarily occurred. Without unidimensionality there is no assurance that a numerical value represents a coherent quantity. The distinction between aggregation and measurement is therefore fundamental. Numbers can always be combined. Measures cannot be assumed.

Equally important is the distinction between manifest and latent attributes. Manifest attributes are directly observable and, where appropriately specified, support linear ratio measurement. Latent attributes are not directly observable and require a measurement model capable of estimating possession of the attribute. In the latter case, the required measure is the Rasch logit ratio scale [4]. These two forms of ratio measurement, linear ratio measurement for manifest attributes and Rasch logit ratio measurement for latent attributes, provide the only scientifically defensible basis for quantitative claims regarding therapy impact.

Taken together, these principles establish a clear standard. Measurement must precede arithmetic. Scale properties determine admissible operations. Ratio measurement is required wherever proportional comparisons or multiplication are involved. Unidimensionality must be demonstrated before measurement can be claimed. Representational measurement provides the governing scientific framework. Any discipline seeking to generate quantitative claims must satisfy these requirements. Without them, numerical outputs remain constructions rather than measures, and quantitative claims become matters of assumption rather than science.

CURRICULUM EXPECTATIONS

A curriculum intended to prepare students for health technology assessment should provide more than instruction in economic evaluation, evidence synthesis, utility assessment, and simulation modelling. It should equip students with the conceptual tools necessary to evaluate the scientific legitimacy of quantitative claims.

At a minimum, students should be introduced to the role of attributes in therapy assessment and the requirement that the target attribute be specified before evaluation begins. They should understand the principal scales of measurement and the implications these have for admissible arithmetic. They should be familiar with the distinction between nominal, ordinal, interval, and ratio scales and appreciate that different scales support different forms of analysis.

A scientifically grounded curriculum should also introduce students to representational measurement and its role in determining whether numerical assignments constitute valid measures. This includes an understanding of the relationship between measurement and arithmetic, the importance of unidimensionality, and the conditions required for quantitative claims.

Students should further be expected to recognize the distinction between manifest and latent attributes. Observable outcomes such as survival, hospital admissions, adverse events, and treatment persistence present different measurement challenges from latent constructs such as pain, fatigue, quality of life, functioning, and patient satisfaction. A curriculum should therefore provide an understanding of the different measurement frameworks required for these two classes of attributes.

Finally, students should be exposed to the principles of empirical evaluation and falsification. Quantitative claims should not be treated as self-validating simply because they are numerical. Rather, students should understand that scientific claims must be capable of evaluation, replication, and potential refutation through observation and evidence.

These expectations do not represent advanced or specialist topics. They constitute the foundational knowledge required for any discipline that seeks to support quantitative claims regarding therapy impact. Their presence would indicate a curriculum grounded in measurement and scientific inquiry. Their absence would suggest that students are being trained to apply analytical techniques without first acquiring the conceptual framework necessary to evaluate whether the resulting claims are scientifically defensible.

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. 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 scientific 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, reviewers, and decision makers. Curriculum inversion therefore becomes the educational mechanism through which measurement inversion is institutionalized within a discipline.

The importance of curriculum inversion extends beyond education. Universities and research centers are responsible for training the individuals who subsequently populate HTA agencies, reimbursement committees, consulting organizations, professional societies, and academic departments. If the concepts necessary to evaluate quantitative claims are absent from the curriculum, they will also be absent from research, policy, and practice. The omissions identified in educational programs therefore become embedded throughout the wider HTA environment. What begins as a curriculum deficiency ultimately becomes a disciplinary norm.

For this reason, curriculum assessment is a critical component of any evaluation of the scientific standing of HTA. 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 evaluation of those methods possible. A curriculum that emphasizes modelling, economic evaluation, utility assessment, and decision analysis while neglecting measurement theory will inevitably reproduce the same conceptual limitations observed in current HTA practice.

This is why curriculum inversion provides an important explanation for the persistence of the reference-case paradigm. Utilities, QALYs, cost-effectiveness ratios, and simulation models have survived not because their measurement foundations were demonstrated, but because the concepts required to challenge those foundations were largely absent from the educational environment. Curriculum inversion reproduces measurement inversion. Together they explain how a framework built on arithmetic before measurement could become established, institutionalized, and defended for more than four decades.

DEFINING THE AUSTRIAN KNOWLEDGE BASE

The Austrian curriculum knowledge base for health technology assessment is concentrated, technically sophisticated, and closely connected to wider European HTA methodology. It is formed through the combined educational and methodological activity of the Austrian Institute for Health Technology Assessment, UMIT Tirol, the Medical University of Vienna, the Institute for Advanced Studies, the Austrian National Public Health Institute, and associated university, policy, and professional networks. Unlike larger jurisdictions where HTA education is dispersed across many universities and research centers, Austria has a smaller but highly identifiable HTA community. This makes the curriculum knowledge base easier to define, but it also means that a relatively limited number of institutions can exercise substantial influence over how future practitioners understand HTA.

The Austrian Institute for Health Technology Assessment occupies a central position. Through its assessments, methodological reports, policy-facing work, and participation in international HTA networks, it helps define the applied language of Austrian HTA. The emphasis is on evidence synthesis, comparative effectiveness, health economic evaluation, decision support, reimbursement relevance, and the translation of evidence into policy. These are the topics most likely to be visible to students, researchers, agency staff, and professional audiences engaging with Austrian HTA.

UMIT Tirol provides the most explicit academic base for HTA teaching and training. Its work in public health, medical decision making, health services research, health economics, and HTA places it at the centre of Austrian curriculum formation. It is especially important because it links HTA to decision analysis, modelling, epidemiology, clinical evaluation, and health policy. The Medical University of Vienna, the Institute for Advanced Studies, and the Austrian National Public Health Institute further reinforce this knowledge base through health economics, public health, epidemiology, outcomes research, and health systems analysis.

The resulting curriculum knowledge base is therefore not methodologically weak in the usual sense. Austria has considerable technical competence in evidence appraisal, health economic modelling, clinical evaluation, policy analysis, and reimbursement-relevant assessment. The problem identified by the curriculum interrogation is different. It concerns the ordering of knowledge. Students and practitioners appear to encounter the established procedures of contemporary HTA before they encounter the scientific principles required to determine whether those procedures can support lawful quantitative claims.

The interrogation therefore treats the Austrian curriculum knowledge base as a collective educational environment rather than as a single syllabus. The relevant question is whether that environment gives foundational priority to attributes, target attribute specification, scale types, representational measurement, unidimensionality, the distinction between manifest and latent attributes, lawful ratio measurement, Rasch measurement, and falsifiable therapy-impact claims. The evidence suggests that it does not. Instead, the curriculum knowledge base normalizes the reference-case vocabulary of utilities, QALYs, cost-effectiveness analysis, decision modelling, and reimbursement support without first establishing whether the quantities entering those analyses satisfy the requirements of measurement.

This is the basis for identifying curriculum inversion in Austria. The Austrian curriculum knowledge base teaches the methods of HTA before teaching the measurement standards required to evaluate them. As a result, technical competence may be developed without measurement competence. In a discipline that claims to support quantitative decisions, this is not a minor educational omission. It is the mechanism through which measurement inversion is reproduced.

INTERROGATING THE CURRICULUM KNOWLEDGE BASE

The purpose of the present interrogation is not to determine what a large language model "believes." Large language models possess no beliefs, opinions, or independent understanding. Their value lies in their ability to interrogate and summarize the conceptual content of a defined knowledge base. The objective is therefore to examine the intellectual environment represented within a curriculum and to determine which concepts are present, absent, weakly represented, or strongly reinforced.

In the context of curriculum assessment, the knowledge base is defined as the totality of publicly accessible materials through which a research center communicates educational and methodological content. These materials include curriculum descriptions, course outlines, learning objectives, training programs, methodological guidance documents, workshop and seminar content, faculty publications, doctoral training resources, technical reports, conference presentations, and other educational materials associated with the institution. Taken together, these sources provide a representation of the concepts and analytical frameworks that students, researchers, and professional staff are most likely to encounter.

The interrogation therefore focuses not on individual instructors or specific courses but on the broader intellectual environment that the curriculum creates and sustains. A curriculum functions as a mechanism for transmitting knowledge across successive generations of students and researchers. Concepts that are consistently emphasized become embedded within professional practice. Concepts that are absent or weakly represented are unlikely to become part of the analytical framework employed by future practitioners. The curriculum knowledge base therefore provides an important indicator of the intellectual foundations of a discipline.

For the purposes of the present assessment, the objective is straightforward: to determine the extent to which the curriculum knowledge base recognizes and reinforces the concepts required for a measurement-based approach to health technology assessment. Particular attention is given to attributes, measurement scales, representational measurement, admissible arithmetic, unidimensionality, the distinction between manifest and latent attributes, ratio measurement, Rasch measurement, and the requirement that scientific claims be evaluable and potentially falsifiable. These concepts constitute the foundational framework necessary for evaluating the validity of quantitative claims.

The interrogation proceeds through a series of canonical statements representing concepts that would be expected to appear within a curriculum grounded in measurement science. The resulting endorsement probabilities provide an indication of the extent to which these concepts are embedded within the curriculum knowledge base. High endorsement probabilities suggest that the concept is visible and reinforced within the educational environment. Low endorsement probabilities suggest that the concept is absent, weakly represented, or largely ignored.

The significance of this approach is that it allows the curriculum to be evaluated as a coherent intellectual system rather than as a collection of individual courses. The question is not whether students are taught contemporary HTA methods. The question is whether they are taught the concepts necessary to evaluate the scientific legitimacy of those methods. The resulting profile provides a measure of the extent to which the curriculum supports, neglects, or potentially undermines the foundations of measurement-based scientific inquiry.

TOOLS FOR INTERROGATION

The identification of measurement inversion across HTA research centers, reimbursement agencies and academic programs raises an obvious question: where does this inversion originate?

The objective of 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

Together they define the minimum curriculum content required for a measurement-based approach to HTA and provide the framework for evaluating curriculum coverage in these UK HTA research centers.

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.

ENDORSEMENT OF CURRICULUM INVERSION IN AUSTRIA

The Austrian curriculum knowledge base demonstrates a strong pattern of curriculum inversion. Across the ten canonical statements, the concepts required for measurement-based HTA receive consistently weak endorsement. Austrian HTA education and training appear to emphasize evidence synthesis, comparative effectiveness, health economic evaluation, decision analysis, cost-effectiveness, reimbursement relevance, and policy support before establishing the measurement foundations required for lawful quantitative claims.

This finding is important because Austria has a sophisticated HTA and health economics environment. The Austrian Institute for Health Technology Assessment, UMIT Tirol, the Medical University of Vienna, the Institute for Advanced Studies, and the Austrian public health infrastructure contribute to a technically advanced knowledge base. The weakness identified by the interrogation is therefore not technical inadequacy. It is the ordering of the curriculum. Students and practitioners are introduced to the procedures of HTA before they are introduced to the standards required to determine whether the quantities entering those procedures are measures.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT - AUSTRIA

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

The weakest results concern the axioms of representational measurement and the distinction between the ratio requirements for manifest and latent attributes. These are decisive omissions. If representational measurement is absent, there is no explicit framework for determining whether numerical assignments preserve the structure of the attribute being measured. If manifest and latent attributes are not distinguished, observable clinical endpoints, patient-reported outcomes, utilities, QALYs, preference weights, and model outputs can all be treated as though they possess comparable measurement status.

The results also indicate weak recognition that the measurement status of the target attribute must be established before quantitative claims are advanced. This is the core of curriculum inversion. The curriculum develops competence in applying HTA methods without first developing competence in evaluating whether those methods can support lawful quantitative claims.

The implication for Austria is clear. HTA education should be reconstructed around first principles: specification of the target attribute, scale type, representational measurement, unidimensionality, the manifest-latent distinction, lawful ratio measurement, and falsifiable therapy-impact claims. Without this reconstruction, Austrian HTA education will continue to reproduce measurement inversion through curriculum inversion.

STATEMENT-BY-STATEMENT REVIEW

Statement 1. An attribute is the specific outcome of interest in a therapy assessment. Probability 0.20 (Logit –1.40)

The Austrian curriculum knowledge base demonstrates only limited recognition that every quantitative assessment must begin by identifying the attribute to be measured. Discussion is generally organized around concepts such as clinical effectiveness, patient-reported outcomes, quality of life, economic evaluation, or value assessment rather than around the explicit specification of the target attribute. Consequently, the attribute itself is not presented as the central scientific object of measurement upon which all subsequent analysis depends.

Statement 2. Every therapy assessment begins with specification of the target attribute.
Probability 0.15 (Logit –1.75)

The interrogation indicates that Austrian HTA education introduces students to evidence assessment, comparative effectiveness, economic evaluation, and reimbursement methodology before emphasizing specification of the target attribute. The logical sequence required by representational measurement is therefore reversed. Rather than first defining what is to be measured, the curriculum proceeds directly to the analytical methods used to evaluate therapies.

Statement 3. The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis.
Probability 0.15 (Logit –1.75)

Recognition of the principal scales of measurement is weak. Statistical analysis receives considerable attention, yet there is little indication that students are taught that the admissibility of arithmetic depends upon the measurement properties of the underlying scale. Without this understanding, numerical analyses may be accepted simply because they are mathematically sophisticated rather than because they are scientifically admissible.

Statement 4. The measurement status of a target attribute must be established before quantitative claims can be advanced.
Probability 0.10 (Logit –2.20)

This statement receives one of the weakest endorsements. The curriculum appears to assume that numerical outputs generated from clinical studies, utilities, questionnaires, composite indices, or economic models already constitute measures. The prior scientific requirement—that the measurement properties of the target attribute must first be demonstrated—is largely absent. Measurement is effectively assumed rather than established.

Statement 5. The axioms of representational measurement underpin quantitative claims.
Probability 0.05 (Logit –2.50)

This represents the strongest evidence of curriculum inversion. The interrogation found virtually no recognition that quantitative claims derive their legitimacy from the axioms of representational measurement. Concepts such as admissible transformations, dimensional homogeneity, cancellation, solvability, and empirical relational structures are largely absent from the curriculum knowledge base. Quantitative analysis therefore proceeds without explicit reference to the scientific principles that make quantitative analysis possible.

Statement 6. Attributes must be demonstrated to be unidimensional before measurement is possible.
Probability 0.10 (Logit –2.20)

The concept of unidimensionality receives little explicit attention. Patient-reported outcomes and quality-of-life instruments are discussed largely in terms of reliability, validity, responsiveness, or preference weighting rather than whether they measure a single latent attribute. Yet without demonstration of unidimensionality, quantitative measurement of latent constructs cannot be justified.

Statement 7. A manifest attribute is directly observable and capable of supporting empirical observation.
Probability 0.20 (Logit –1.40)

The curriculum demonstrates partial recognition of observable outcomes such as mortality, hospital admissions, adverse events, laboratory measurements, treatment persistence, and healthcare resource utilization. However, these outcomes are rarely presented explicitly as manifest attributes possessing their own measurement properties. Consequently, the conceptual importance of manifest measurement remains underdeveloped.

Statement 8. A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute.
Probability 0.15 (Logit –1.75)

Although Austrian HTA education recognizes patient-reported outcomes, quality of life, and other subjective constructs, there is little evidence that students are taught that these represent latent attributes requiring an explicit measurement model. The curriculum generally proceeds directly from ordinal questionnaire responses to scoring systems, utilities, or composite indices without first addressing the measurement problem itself.

Statement 9. Manifest and latent attributes require different forms of ratio measurement.
Probability 0.05 (Logit –2.50)

This is the weakest conceptual area identified by the interrogation. There is virtually no indication that Austrian curricula distinguish between the measurement requirements of observable and latent attributes. The unique roles of linear ratio measures for manifest attributes and Rasch logit ratio measures for latent attributes are absent. This omission removes one of the principal scientific foundations for lawful quantitative assessment and permits fundamentally different forms of evidence to be treated as though they possess equivalent measurement properties.

Statement 10. Therapy impact claims must be falsifiable.
Probability 0.15 (Logit –1.75)

The curriculum demonstrates only weak recognition that quantitative claims should be prospectively evaluable, independently replicable, and capable of falsification. While evidence-based medicine emphasizes critical appraisal and uncertainty, there is little indication that individual therapy-impact claims are expected to function as scientific hypotheses open to empirical refutation. Instead, attention is directed toward interpretation of published evidence and model outputs rather than construction of claims capable of subsequent empirical testing. This completes the pattern of curriculum inversion identified throughout the Austrian HTA knowledge base.

A PATH FORWARD

Recognition that the reference-case paradigm is incompatible with the requirements of representational measurement inevitably raises an important practical question. If utilities, QALYs, and reference-case simulation models cannot support lawful quantitative claims regarding therapy impact, what analytical framework should replace them?

The answer is that a scientifically coherent alternative is available. Rather than relying upon composite ordinal scores and assumption-driven simulation models, a measurement-based approach to HTA begins by identifying the target attribute and selecting the appropriate form of measurement. Two forms of ratio measurement provide the foundation for all scientifically defensible HTA claims: linear ratio measures for directly observable (manifest) attributes and Rasch logit ratio measures for latent attributes that require a measurement model to estimate possession. Together, these provide the only admissible basis for quantitative claims regarding therapy impact that are prospectively evaluable, replicable, and potentially falsifiable.

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.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN AUSTRIA

The companion interrogation of the Austrian HTA knowledge base demonstrated that contemporary health technology assessment in Austria is characterized by measurement inversion. The accepted principles of representational measurement receive little recognition, while utilities, QALYs, cost-effectiveness analysis, and reference-case simulation modelling continue to be accepted as though they provide scientifically valid quantitative measures of therapy impact. The present study has addressed the complementary question of how this analytical framework became established and, more importantly, how it continues to reproduce itself. The evidence points to a single conclusion: curriculum inversion.

The interrogation demonstrates that the Austrian curriculum knowledge base introduces future 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, evidence synthesis, health economic evaluation, utilities, QALYs, decision modelling, reimbursement methodology, and policy support rather than upon specification of the target attribute, the principal scales of measurement, representational measurement, admissible arithmetic, unidimensionality, the distinction between manifest and latent attributes, lawful ratio measurement, Rasch measurement, and the requirement that quantitative claims be prospectively evaluable, independently replicable, and capable of falsification. Graduates therefore acquire technical competence in the application of HTA while never being equipped to determine whether the quantities entering those analyses satisfy the accepted standards of quantitative science.

This finding explains the persistence of the contemporary reference-case paradigm throughout Austrian HTA. Measurement inversion has not survived because its scientific foundations have been critically examined and confirmed. Rather, it has survived because the educational framework provides little opportunity for students or practitioners to encounter the principles required to undertake such an examination. Successive generations of university graduates, HTA researchers, consultants, policy analysts, reimbursement advisers, and industry specialists inherit an analytical framework in which the measurement assumptions underpinning utilities, QALYs, and simulation models remain largely invisible. Curriculum inversion therefore becomes the educational mechanism through which measurement inversion is continuously reproduced.

The implications extend beyond individual universities and research institutes. Austria occupies an influential position within the European HTA community through the Austrian Institute for Health Technology Assessment, UMIT Tirol, the Medical University of Vienna, the Institute for Advanced Studies, the Austrian National Public Health Institute, and extensive collaboration with European HTA initiatives. Consequently, the curriculum transmitted within Austria contributes not only to national professional development but also to the wider European methodological tradition. If curriculum inversion remains embedded within Austrian HTA education, it inevitably reinforces measurement inversion throughout that wider community.

The implications for universities are equally important. Universities have a responsibility not merely to teach accepted methods but to ensure that students understand the scientific conditions under which those methods are valid. Continuing to teach the reference-case paradigm without making clear that it fails the accepted standards of representational measurement risks graduating professionals who are technically proficient in methods that cannot support lawful quantitative claims regarding therapy impact. This does not serve students, employers, health-care decision makers, or the long-term scientific reputation of Austrian institutions.

The evidence presented in the companion papers therefore leaves little scope for incremental refinement. The challenge facing Austrian HTA is not one of constructing more sophisticated economic models, improving utilities, refining QALY algorithms, incorporating additional real-world evidence, or expanding simulation techniques. These initiatives leave untouched the more fundamental question of whether the quantities entering those analyses are measures. Measurement must precede arithmetic. Unless lawful measurement has first been established, increasingly sophisticated calculations merely produce increasingly sophisticated numerical constructions.

The way forward is both scientifically clear and practically achievable. HTA education should begin with the specification of the target attribute, determination of whether that attribute is manifest or latent, application of the appropriate form of ratio measurement, and construction of therapy-impact claims that are prospectively evaluable, independently replicable, and capable of falsification. Manifest attributes require linear ratio measures; latent attributes require Rasch logit ratio measures. Only after these conditions have been satisfied should economic evaluation and decision modelling be introduced.

Austria possesses the academic capability to lead this transition. Its universities, HTA institutes, research centers, and public health organizations have the expertise required to reconstruct HTA education around the principles of representational measurement. Such a transition would not simply improve Austrian HTA. It would provide future generations of students with the scientific competencies expected of every quantitative discipline while strengthening Austria's contribution to the future development of measurement-based health technology assessment throughout Europe.

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