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MODEL INTERROGATION**



**REPRESENTATIONAL MEASUREMENT FAILURE IN
HEALTH TECHNOLOGY ASSESSMENT**

**SWITZERLAND: CURRICULUM INVERSION IN
HEALTH TECHNOLOGY ASSESSMENT**

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ABSTRACT

Health technology assessment (HTA) depends upon the ability to make scientifically defensible quantitative claims regarding therapy impact. A companion interrogation of the Swiss HTA knowledge base demonstrated that the contemporary reference-case paradigm is characterized by measurement inversion, with utilities, QALYs, cost-effectiveness analysis, and simulation modelling accepted despite failing the requirements of representational measurement. The obvious question therefore arises: how has this framework been reproduced so consistently within Swiss HTA? This study argues that the answer lies in curriculum inversion.

Using a structured large language model interrogation of the Swiss HTA curriculum knowledge base, the study evaluates whether students are taught the scientific foundations of quantitative measurement before they are introduced to the established methods of HTA. Ten canonical statements covering attributes, target attribute specification, scales of measurement, representational measurement, unidimensionality, manifest and latent attributes, lawful ratio measurement, and falsifiable therapy-impact claims provide the basis for the assessment.

The results demonstrate a consistent pattern of curriculum inversion. The concepts that underpin lawful quantitative assessment receive uniformly weak endorsement, while curricula emphasize evidence synthesis, economic evaluation, utilities, QALYs, decision modelling, and reimbursement analysis. Students therefore acquire technical proficiency in the reference-case paradigm without first acquiring the scientific competencies required to determine whether its quantitative claims are lawful. Curriculum inversion thus provides the educational mechanism through which measurement inversion is transmitted from one generation of practitioners to the next.

The implications extend well beyond curriculum design. Universities have a responsibility to ensure that graduates possess the scientific competencies expected of any quantitative discipline. Continuing to teach the reference-case paradigm without clearly identifying its failure to satisfy the standards of representational measurement risks preparing graduates for methods that cannot support scientifically defensible claims regarding therapy impact. At the same time, Swiss universities, HTA organizations, and professional societies have an opportunity to lead the international transition to a measurement-based framework founded upon representational measurement, lawful linear ratio and Rasch logit ratio measurement, and prospectively evaluable, independently replicable, and falsifiable claims. Such a transition would strengthen the scientific standing of Swiss HTA while providing students with the competencies required for the next generation of health technology assessment.

INTRODUCTION

A large language model (LLM) interrogation of the Swiss health technology assessment (HTA) knowledge base has demonstrated strong endorsement of measurement inversion ¹. Across national HTA guidance, academic research, university teaching, methodological publications, and professional practice, 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 accepted as though they provide scientifically valid measures of therapy impact. These findings indicate that measurement inversion is not confined

to individual universities, research groups, or assessment organizations but characterizes the Swiss HTA knowledge base as a whole.

The present study addresses the complementary question of whether this pervasive pattern of measurement inversion is accompanied by curriculum inversion. This is a critical issue because evidence from Australia, Canada, France, Germany, Italy, the Netherlands, New Zealand, Spain, the United Kingdom, the United States, and the European Union demonstrates that measurement inversion is sustained through the educational framework responsible for preparing successive generations of HTA practitioners. Switzerland occupies a particularly important position within European health economics and HTA. Swiss universities, research institutes, and professional organizations have made significant contributions to economic evaluation, health outcomes research, evidence synthesis, and reimbursement methodology. Consequently, if the scientific foundations of quantitative measurement are absent from Swiss HTA education, curriculum inversion becomes an important mechanism through which measurement inversion is reproduced not only nationally but also through Switzerland's broader influence on international HTA methodology.

The purpose of this interrogation is therefore to determine whether the Swiss HTA curriculum knowledge base introduces students and practitioners to the scientific foundations of representational measurement before presenting the established methods of contemporary HTA. In particular, the interrogation examines whether curricula begin with specification of the target attribute, the principal scales of measurement, the axioms of representational measurement, the distinction between manifest and latent attributes, lawful ratio measurement, Rasch measurement for latent constructs, and the requirement that quantitative claims be prospectively evaluable, independently replicable, and capable of falsification. Only after these foundations have been established can utilities, QALYs, economic evaluation, and decision modelling be introduced as potential analytical techniques.

The interrogation reveals a consistent pattern of curriculum inversion within the Swiss HTA curriculum knowledge base. Across the ten canonical statements, the concepts that should provide the scientific foundation for quantitative assessment receive uniformly weak endorsement. The curriculum emphasizes evidence synthesis, comparative effectiveness, health economic evaluation, utilities, QALYs, and decision modelling while providing little recognition of the measurement principles required to determine whether those methods can support lawful quantitative claims. Students are therefore taught how to apply established HTA techniques before they are taught the scientific standards necessary to evaluate the validity of those techniques.

These findings closely parallel those of the companion paper on measurement inversion. There, the Swiss 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 Swiss 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 scales². 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 measurement³. 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 scale⁴. 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 SWISS KNOWLEDGE BASE

The Swiss curriculum knowledge base for health technology assessment (HTA) is distinctive because it is academically strong, institutionally dispersed, and closely linked to wider European health economics and evidence-assessment traditions. Unlike jurisdictions with a single dominant HTA agency that also shapes much of the educational framework, Switzerland draws upon a distributed network of universities, applied science institutions, public health institutes, clinical epidemiology units, health economics groups, and policy-facing organizations. The relevant curriculum knowledge base therefore cannot be located in one institution. It is formed through the combined teaching, research, guidance, professional training, and methodological literature produced across the Swiss HTA and health economics community.

Several institutional clusters are particularly important. The University of Basel contributes through health economics, pharmaceutical medicine, clinical research, and public health. The University of Zürich, especially through epidemiology, biostatistics, public health, and clinical evaluation, has a major role in evidence generation and appraisal. The University of Lucerne has become increasingly important through its Faculty of Health Sciences and Medicine, with strengths in health economics, health services research, rehabilitation sciences, health behaviour, and health policy. Lausanne and Geneva contribute through public health, epidemiology, medical informatics, health services research, and policy analysis. The Swiss Tropical and Public Health Institute adds further methodological depth, particularly in epidemiology, population health, and global health evaluation. Zurich University of Applied Sciences and other applied institutions contribute through health economics, cost analysis, service evaluation, and implementation-oriented research.

This knowledge base is reinforced by national HTA and reimbursement structures. Switzerland has developed formal HTA processes within the federal policy environment, where assessments are expected to support decisions concerning effectiveness, appropriateness, economic consequences, and reimbursement. The Swiss system therefore encourages educational attention to evidence synthesis, clinical effectiveness, comparative assessment, cost-effectiveness, resource use, health economic modelling, and decision support. These topics are visible across professional training, postgraduate programs, research seminars, health economics teaching, public health curricula, and policy-facing publications.

The importance of this curriculum knowledge base lies precisely in its sophistication. Swiss HTA education is not methodologically primitive. On the contrary, it reflects advanced competence in epidemiology, economic evaluation, health services research, modelling, and clinical evidence appraisal. The problem identified by the curriculum interrogation is therefore not a lack of

technical expertise. It is the ordering of that expertise. Students and practitioners are introduced to the established instruments of contemporary HTA before they are introduced to the scientific principles required to determine whether those instruments can support lawful quantitative claims.

The interrogation therefore treats the Swiss curriculum knowledge base as a collective educational environment rather than as a single syllabus. It asks whether that environment gives foundational priority to attributes, scale types, representational measurement, unidimensionality, the distinction between manifest and latent attributes, lawful ratio 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, economic evaluation, cost-effectiveness and modelling without first establishing whether the quantities entering those analyses satisfy the standards required for measurement. In this respect, Swiss HTA education exhibits the same pattern observed internationally: curriculum inversion provides 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 SWITZERLAND

The interrogation indicates a strong pattern of inversion in the Swiss HTA curriculum knowledge base (Table 1). The foundational concepts required for lawful quantitative assessment are weakly represented. The curriculum appears more likely to emphasize clinical effectiveness, cost-effectiveness, economic evaluation, systematic review, reimbursement relevance, and decision support than the prior scientific requirements for measurement

The weakest findings concern representational measurement and the distinction between the ratio requirements for manifest and latent attributes. These are not minor omissions. If the axioms of representational measurement are absent, then students are not provided with the scientific framework required to determine whether quantitative claims are lawful. If manifest and latent attributes are not distinguished as requiring different forms of ratio measurement, then clinical endpoints, patient-reported outcomes, utilities, QALYs, preference weights, and economic model outputs can all be treated as though they possess comparable measurement status.

The results also indicate weak recognition of the requirement that measurement status must be established before quantitative claims are advanced. This is the central feature of curriculum inversion. Students and practitioners are introduced to the analytical methods of HTA before they are taught the standards required to evaluate whether the quantities entering those methods are measures. As a result, technical proficiency in HTA may be developed without scientific competence in measurement.

The implication for Switzerland 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 that sequence, the Swiss curriculum knowledge base will continue to reproduce measurement inversion through curriculum inversion.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT - SWITZERLAND

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

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 Swiss curriculum knowledge base demonstrates only limited recognition that every quantitative assessment begins with explicit specification of the attribute to be measured. Outcomes are more commonly presented under broad headings such as clinical effectiveness, patient-reported outcomes, quality of life, utility assessment, or value assessment without emphasizing that each represents a distinct attribute requiring independent specification. As a result, the attribute itself does not emerge as the central organizing concept for therapy assessment.

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

The interrogation suggests that Swiss HTA education begins with assessment frameworks, evidence synthesis, and economic evaluation rather than with identification of the target attribute. The consequence is that analytical methods are introduced before students consider precisely what is being measured. Specification of the target attribute is therefore not presented as the first scientific step in quantitative assessment.

**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 properties of the principal scales of measurement appears weak. Although statistical methods are widely taught, there is little indication that curricula emphasize the restrictions imposed by different scale types or their implications for permissible arithmetic. Students are therefore unlikely to appreciate that arithmetic operations are determined by measurement properties rather than by analytical preference.

**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 represents one of the clearest examples of curriculum inversion. The curriculum appears to assume that numerical outputs generated from clinical studies, utility instruments, or economic models already constitute measures. The prior scientific requirement—that the measurement properties of the underlying attribute must first be demonstrated—is largely absent.

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

The interrogation found virtually no evidence that representational measurement provides the conceptual foundation for HTA education. Concepts such as admissible transformations, cancellation, solvability, dimensional homogeneity, or the relationship between empirical and numerical relational structures receive little or no explicit attention. Consequently, quantitative claims are presented without reference to the scientific framework that legitimizes them.

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

The concept of unidimensionality is only weakly represented. Patient-reported outcomes and quality-of-life instruments are discussed largely in terms of validity, reliability, responsiveness, or preference weighting rather than whether they measure a single underlying attribute. Without unidimensionality, lawful quantitative measurement of latent attributes cannot be established.

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

Probability 0.20 (Logit -1.40)

The curriculum demonstrates some recognition of observable clinical endpoints such as mortality, hospital admissions, adverse events, laboratory values, and resource utilization. However, these outcomes are rarely presented explicitly as manifest attributes possessing distinct measurement properties. The conceptual significance of manifest attributes therefore remains only partially developed.

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)

Swiss HTA education recognizes the importance of patient-reported outcomes and quality-of-life assessment but provides little indication that latent attributes require an explicit measurement model before quantitative claims can be advanced. Ordinal questionnaire responses are generally treated as suitable inputs for utility generation or composite scoring without addressing the prior problem of measurement.

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 evidence that Swiss curricula distinguish between the measurement requirements of manifest and latent attributes. The unique role of linear ratio measures for observable attributes and Rasch logit ratio measures for latent attributes is absent. This omission removes one of the principal scientific foundations for lawful therapy assessment.

Statement 10. Therapy impact claims must be falsifiable.

Probability 0.15 (Logit -1.75)

Although evidence-based medicine emphasizes critical appraisal and uncertainty, the curriculum provides little indication that individual quantitative claims regarding therapy impact should be prospectively evaluable, independently replicable, and capable of falsification. Instead, emphasis is placed upon interpretation of published evidence and model outputs rather than on constructing claims that can subsequently be tested empirically. This weak recognition of falsifiability completes the pattern of curriculum inversion identified throughout the Swiss 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

The companion interrogation of the Swiss HTA knowledge base demonstrated that contemporary health technology assessment in Switzerland 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 such a framework became established and, more importantly, how it has been reproduced with such consistency. The evidence points to a single conclusion: curriculum inversion.

The interrogation demonstrates that the Swiss curriculum knowledge base introduces future HTA practitioners to the technical procedures of evidence synthesis, health economic evaluation, utilities, QALYs, decision modelling, and reimbursement analysis before introducing them to the scientific principles required to determine whether those methods can support lawful quantitative claims. Fundamental concepts including 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, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification receive consistently weak endorsement. Students therefore learn how to perform HTA before they learn how to determine whether HTA has produced scientifically valid measures.

This finding explains the persistence of the contemporary reference-case paradigm within Swiss HTA. Measurement inversion has not endured because its scientific foundations have been critically examined and confirmed. It has endured because successive generations of students, researchers, consultants, agency staff, manufacturers, and policy analysts have been educated within a curriculum that largely omits the principles required to evaluate those foundations. Curriculum inversion has therefore become the educational mechanism through which measurement inversion is transmitted from one generation to the next.

The implications extend beyond individual universities or research institutes. Switzerland occupies an influential position within European health economics, outcomes research, and HTA. Swiss universities, HTA organizations, public health institutes, and professional societies contribute not only to national policy but also to the wider European methodological community. Consequently, curriculum inversion within Switzerland has implications extending well beyond its national boundaries. A curriculum that gives priority to technical proficiency over scientific measurement inevitably reinforces the same assumptions throughout the broader HTA community.

The consequences for universities are equally important. Universities have a responsibility not merely to transmit established methods but to ensure that graduates 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 competent in procedures that cannot support lawful quantitative claims. This is ultimately a disservice to students, to employers, to healthcare decision makers, and to the scientific reputation of the institutions themselves.

The evidence presented in the companion papers therefore leaves little room for incremental adjustment. The challenge facing Swiss HTA is not one of refining utilities, improving QALY algorithms, expanding evidence synthesis, or developing increasingly sophisticated simulation models. None of these activities addresses the more fundamental question of whether the quantities entering those analyses satisfy the accepted standards of measurement. Arithmetic cannot compensate for the absence of measurement. More elaborate models simply produce more elaborate calculations based upon quantities that are not measures.

The way forward is equally clear. HTA education should begin with the scientific foundations of quantitative assessment: specification of the target attribute, identification of whether the attribute is manifest or latent, application of the appropriate form of ratio measurement, and construction of claims that are prospectively evaluable, independently replicable, and capable of falsification. Only after lawful measurement has been established should economic evaluation and decision modelling be introduced.

Switzerland is exceptionally well placed to lead this transition. Its universities, HTA organizations, and research institutes possess the academic strength and international standing to restore measurement to its proper place as the foundation of health technology assessment. By replacing curriculum inversion with a measurement-based educational framework, Swiss HTA can move beyond the limitations of the reference-case paradigm and provide future generations of students with the scientific competencies expected of every quantitative discipline. In doing so, Switzerland

would not simply reform its own curriculum; it could help lead the wider international transition toward a scientifically defensible framework for health technology assessment.

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