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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY 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 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 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.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF SWISS HTA

A central finding of the Swiss curriculum interrogation is the absence of any explicit framework distinguishing manifest from latent attributes and the corresponding measurement requirements that follow from this distinction. This omission is particularly significant because the distinction between manifest and latent attributes is not a methodological refinement but one of the foundational concepts of representational measurement. Without it there is no coherent basis for determining how therapy outcomes should be measured, what constitutes a lawful quantitative claim, or whether the arithmetic applied within HTA is scientifically admissible.

Manifest attributes are directly observable. Their existence and magnitude can be established through empirical observation without the need for an intervening measurement model. Examples include survival time, hospital admissions, emergency department visits, medication adherence, treatment discontinuation, adverse events, laboratory values, and healthcare resource utilization. These attributes are observable phenomena that can be counted, timed, or otherwise recorded directly. When properly specified, they support linear ratio measures with a meaningful zero and lawful arithmetic operations. The scientific task is straightforward: define the attribute, establish the unit of observation, specify the observation period, and subject the resulting claim to empirical evaluation and independent replication.

Latent attributes present a fundamentally different measurement problem. Pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, health confidence, and need fulfilment cannot be observed directly. Their existence must be inferred from observable indicators, typically responses to structured questionnaire items. Consequently, latent attributes require a measurement model capable of estimating possession of the attribute while satisfying the axioms of representational measurement. Within HTA this requirement is met through Rasch measurement, which provides a logit ratio measure possessing the properties required for lawful quantitative inference.

The importance of this distinction cannot be overstated. Manifest attributes require linear ratio measures, whereas latent attributes require Rasch logit ratio measures. These are the only two measurement frameworks capable of supporting lawful quantitative claims regarding therapy impact. The distinction therefore determines the entire measurement strategy adopted within HTA.

The interrogation suggests that the Swiss curriculum knowledge base does not recognize this distinction as an organizing principle for HTA education. Instead, outcomes are grouped within broad categories such as patient-reported outcomes, health-related quality of life, clinical outcomes, utility assessment, health economics, economic evaluation, and health-services research. These categories are descriptively useful but scientifically inadequate because they fail to distinguish between directly observable attributes and attributes requiring a measurement model. The measurement requirements governing each class of outcome consequently remain obscured.

Once this distinction disappears, virtually any numerical output can be treated as though it possesses equivalent measurement status. Utility scores, preference weights, composite indices, symptom scales, clinical observations, resource-use counts, and modelled outcomes are brought together within the same analytical framework despite possessing fundamentally different measurement properties. A numerical value becomes sufficient evidence of quantity. The consequence is a loss of measurement discipline in which numerical construction is mistaken for quantitative measurement.

For Switzerland, this omission is particularly striking. Swiss universities and research institutions have internationally respected traditions in medicine, epidemiology, biostatistics, psychology, psychometrics, health economics, outcomes research, and health-services research. The scientific expertise required to recognize the distinction between observable and latent attributes is therefore available within the Swiss academic system. Yet this expertise has not reorganized mainstream HTA education around the nature of the target attribute and the form of measurement required.

The decentralized character of the Swiss healthcare and academic environment adds a further dimension. Universities, university hospitals, federal institutions, insurers, cantonal structures, assessment activities, research groups, consultants, and the pharmaceutical sector contribute to the wider HTA knowledge base. This institutional diversity might be expected to encourage methodological challenge. In practice, however, the common adoption of international HTA conventions can produce methodological convergence. Utilities, QALYs, cost-effectiveness analysis, patient-reported outcomes, and model-based assessment enter teaching and professional practice as accepted analytical methods without a prior requirement to establish the measurement status of their constituent quantities.

Switzerland has therefore absorbed a wider international HTA framework in which the manifest–latent distinction was never established as a foundational organizing principle. This is especially consequential given Switzerland's scientific reputation. Technical expertise in statistics, econometrics, psychometrics, and clinical research cannot compensate for failure to ask the prior measurement question. Sophisticated methods applied to quantities whose measurement status has not been established remain scientifically inadmissible.

If the distinction between manifest and latent attributes remains absent from Swiss HTA education, the same omission will continue to be reproduced across health-economic research, patient-reported outcome assessment, economic evaluation, reimbursement analysis, consultancy, and professional practice. Switzerland's challenge is therefore not simply to add a module on measurement theory to an already sophisticated curriculum. It is to reorganize HTA education around the target attribute itself. Manifest attributes require linear ratio measurement. Latent attributes require Rasch logit ratio measurement. Until this distinction becomes the organizing principle of Swiss HTA education, curriculum inversion will continue to reproduce the measurement inversion embedded within contemporary HTA.

THE ABSENCE OF RASCH IN SWISS HTA

The absence of the manifest–latent distinction also explains the marginal position of Rasch measurement within the Swiss HTA curriculum knowledge base. If latent attributes are not explicitly recognized as presenting a distinct measurement problem, there is no perceived requirement to introduce the one measurement framework capable of constructing lawful quantitative measures of latent attribute possession. Instead, ordinal questionnaire responses are scored, aggregated, transformed into composite indices and utility values, and subsequently incorporated into quality-adjusted life years (QALYs) as though measurement has already been achieved. The measurement problem is therefore bypassed rather than solved.

From the perspective of curriculum design, this represents curriculum inversion. Students and practitioners are introduced to patient-reported outcomes, health-related quality of life, utility assessment, QALYs, health economic evaluation, cost-effectiveness analysis, and model-based assessment before they are required to distinguish between manifest and latent attributes. Consequently, they are not systematically encouraged to ask the fundamental scientific question that should precede every HTA assessment: What is the target attribute, is it manifest or latent, and which lawful form of ratio measurement is required?

For Switzerland, this omission is particularly striking. Swiss universities and research institutions possess internationally respected expertise in psychology, psychometrics, rehabilitation research, outcomes measurement, epidemiology, biostatistics, health economics, and clinical research. Rasch methods and latent trait approaches are not unknown within the Swiss academic knowledge base. They may be encountered in specialist instrument development, rehabilitation, psychology, educational measurement, and patient-reported outcome research. The scientific expertise required to recognize the latent measurement problem therefore exists. Yet it has not been permitted to reorganize mainstream HTA around the requirements of measurement.

This creates a disciplinary separation similar to that observed in other technically advanced HTA systems. Psychometric researchers address dimensionality, item functioning, invariance, response-category performance, and latent trait estimation. Health economists and HTA practitioners address utilities, QALYs, cost-effectiveness ratios, economic evaluation, and model-based claims. The two traditions coexist, but the measurement requirements of the former do not govern the arithmetic of the latter. The prior question of whether a latent attribute has actually been measured disappears between disciplinary boundaries.

This places Rasch in a unique position. Rasch is not simply another psychometric technique competing with item response theory, PROMIS, classical test theory, utility instruments, or preference-based scoring systems. It addresses a prior scientific problem. Its purpose is to determine whether ordinal observations can be transformed into a quantitative measure of possession of a latent attribute. In doing so, it provides the only established framework capable of demonstrating whether the conditions required for measurement have been satisfied.

The distinction is fundamental. Patient-reported outcomes begin with ordinal responses to questionnaire items describing pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, need fulfilment, and other latent attributes. These responses provide information about order but not quantity. Arithmetic performed directly on ordinal observations cannot create measurement. Summed scores do not create measurement. Averages do not create measurement. Statistical weights and econometric coefficients do not create measurement. Utility algorithms and preference functions do not create measurement. Numerical manipulation cannot substitute for demonstrating that the underlying latent attribute has been measured.

Rasch measurement was developed precisely to solve this problem. Through conjoint calibration of persons and items, the Rasch model estimates their locations on a common latent continuum while simultaneously testing whether the observations satisfy the conditions required for lawful measurement. Unidimensionality, specific objectivity, invariance, item fit, ordered response categories, local independence, and differential item functioning are not optional methodological refinements. They are empirical conditions that must be satisfied before a claim concerning possession of a latent attribute can be sustained. Rasch therefore provides both the measurement model and the empirical tests required to determine whether measurement has actually been achieved.

The interrogation indicates that this perspective is not embedded within the Swiss HTA curriculum knowledge base. Rasch methods may be present within specialist psychometrics, rehabilitation, psychology, outcomes measurement, or instrument-development research, but they do not occupy the required foundational position within mainstream health economics and HTA education. Students and practitioners can be introduced to patient-reported outcomes, multiattribute health-status instruments, utilities, preference weights, QALYs, and economic evaluation without first confronting the latent measurement problem. The educational sequence moves directly from ordinal responses to scoring systems, valuation procedures, econometric algorithms, and economic models. The essential intermediate step of demonstrating that a latent attribute has been measured is bypassed.

The implications are particularly serious because the failure is sequential. Ordinal responses to multidimensional health-state instruments enter preference-valuation procedures. Numerical values assigned to selected health states are used in econometric models, where estimated coefficients are interpreted as utility weights or decrements. These values are subsequently applied to health-state responses and treated as quantitative utilities. Utilities are then multiplied by time to construct QALYs, incremental costs are divided by incremental QALYs to create cost-effectiveness ratios, and the resulting quantities are propagated through simulation models. At each stage involving multiplication or division, ratio measurement is required. That requirement has not been demonstrated. Each inadmissible operation therefore becomes the numerical input to the next.

For Switzerland, this conclusion is difficult to explain as a simple absence of methodological expertise. The relevant expertise exists within a scientifically sophisticated academic environment. The failure lies in its compartmentalization. Measurement science has remained peripheral to the analytical framework of mainstream HTA, while utilities, QALYs, and model-based economic evaluation have proceeded as though numerical construction were sufficient evidence of measurement.

The absence of Rasch measurement is therefore not simply a gap in specialist psychometric teaching. It represents the failure of Swiss HTA education to apply available measurement science to the assessment of latent therapy outcomes. Until Rasch logit ratio measurement occupies its required foundational position, students will continue to learn how to generate utilities, construct QALYs, and populate economic models without first learning how possession of a latent attribute is measured. In a country with Switzerland's scientific resources and traditions, this is not a failure of access to measurement knowledge. It is a failure to require that knowledge where it matters.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN SWITZERLAND

The companion interrogation of the Swiss health technology assessment (HTA) knowledge base demonstrated that contemporary HTA in Switzerland is characterized by measurement inversion. The accepted principles of representational measurement receive little recognition, while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, and model-based economic evaluation continue to be treated as though they provide scientifically valid quantitative measures of therapy impact. The present study has addressed the complementary question of how this framework is transmitted, sustained, and reproduced across successive generations of practitioners. The answer is curriculum inversion.

The interrogation demonstrates that the Swiss HTA curriculum knowledge base introduces students and practitioners to the methods of contemporary HTA before introducing them to the scientific principles required to evaluate those methods. Educational emphasis is placed upon comparative effectiveness, health economics, economic evaluation, utilities, QALYs, decision modelling, evidence synthesis, patient-reported outcomes, and reimbursement assessment rather than upon specification of the target attribute, representational measurement, admissible arithmetic, unidimensionality, manifest and latent attributes, Rasch measurement, dimensional homogeneity, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification. Technical competence is therefore developed without the prior measurement framework necessary to determine whether the resulting quantitative claims are scientifically admissible.

For Switzerland, this conclusion is particularly striking. Swiss universities and research institutions have internationally respected traditions in medicine, psychology, psychometrics, epidemiology, biostatistics, clinical research, health economics, outcomes research, and health-services research. Switzerland cannot readily attribute its measurement failure to an absence of scientific or methodological expertise. The knowledge required to recognize the limitations imposed by scales of measurement, the distinction between observable and latent attributes, and the problems associated with ordinal observations is present within the wider academic system.

The failure lies in the compartmentalization of that expertise. Measurement science, psychometrics, health economics, and HTA have developed as partially separated analytical traditions. Psychometric researchers may examine dimensionality, invariance, item functioning, local independence, and latent trait estimation, while health economists construct utilities, QALYs, cost-effectiveness ratios, and modelled claims. The measurement requirements recognized in one field have not been allowed to govern the arithmetic accepted in another. The result is a scientifically sophisticated academic environment in which mainstream HTA continues to manipulate quantities whose measurement status has never been established.

Curriculum inversion is the mechanism through which this separation is reproduced. Students encounter patient-reported outcomes, health-related quality of life, utility assessment, QALYs, cost-effectiveness analysis, and model-based evaluation as established components of HTA. They are not first required to specify the target attribute, determine whether it is manifest or latent, and establish the appropriate form of ratio measurement. The educational sequence therefore moves from observation to numerical representation and then directly to arithmetic and modelling. The essential intermediate question—has measurement actually been achieved?—is bypassed.

The failure is sequential and cumulative. Ordinal responses to multidimensional health-state instruments enter preference-valuation procedures. Numerical values are assigned to health states and incorporated into econometric models, where estimated coefficients are interpreted as utility weights or decrements. These values are treated as quantitative utilities and multiplied by time to construct QALYs. Incremental costs are divided by incremental QALYs to create cost-effectiveness ratios, and these already compromised quantities are propagated through simulation models. At every critical stage involving multiplication or division, ratio measurement is required. That requirement has not been demonstrated. Each inadmissible operation therefore becomes the input to the next.

This conclusion leaves no room for incremental reform. A framework whose constituent quantities fail the axioms of representational measurement cannot be rescued through improved modelling, better utility instruments, more sophisticated statistical or econometric methods, expanded real-world evidence, richer health data, or increasingly elaborate simulation techniques. None of these developments can create measurement where measurement does not exist. Arithmetic cannot rescue quantities that are not measures. The problem lies beneath the methodology itself.

The implications for Swiss universities are therefore direct. Continuing to educate students in utility assessment, QALY construction, cost-effectiveness analysis, and model-based economic evaluation without first teaching the scientific principles governing lawful measurement is incompatible with the central purpose of higher education. Students should certainly understand the historical importance of utilities, QALYs, patient-reported outcome instruments, and reference-case methods. They should, however, understand them as components of a paradigm that failed to satisfy the accepted requirements of quantitative measurement. They should not be taught that these constructs provide valid measures of therapy impact because they do not.

The implications extend beyond universities. Federal assessment and policy activities, university research groups, health economists, outcomes researchers, consultants, insurers, and the pharmaceutical sector depend upon practitioners trained to construct, review, and interpret economic evaluations and modelled claims. Switzerland's engagement with wider European and international HTA further reinforces these methodological conventions. Universities teach the accepted methods; researchers refine them; manufacturers and consultants construct analyses within the same framework; assessment activities review those analyses using related conventions; and professional demand reinforces the curriculum. At no point is there a systematic requirement to return to the prior scientific question: are the quantities being manipulated lawful measures?

The only scientifically defensible path forward is reconstruction. Every HTA assessment should begin with explicit specification of the target attribute. Manifest attributes should be evaluated through lawful linear ratio measures. Latent attributes should be evaluated through Rasch logit ratio measures that satisfy the axioms of representational measurement. Every quantitative claim should be accompanied by a prospective protocol specifying the attribute, measurement method, comparator, evaluation period, replication strategy, and conditions for empirical falsification. Measurement must precede arithmetic in every assessment without exception.

Taken together, the companion interrogations of measurement inversion and curriculum inversion demonstrate that the methodological framework underpinning Swiss HTA has reached its intellectual limit. It has undoubtedly contributed to evidence synthesis, economic evaluation, health-policy assessment, and administrative decision making. It has not, however, established the scientific legitimacy of the quantities upon which its central quantitative claims depend. The sophistication of the analysis cannot compensate for the absence of lawful measurement. A framework constructed upon measurement impossibilities has no scientific future.

Switzerland now faces a particularly uncomfortable choice. It can continue to reproduce measurement inversion through a curriculum that separates measurement science from HTA practice, or it can apply to HTA the same standards of scientific measurement expected elsewhere in its academic and research system. The future of Swiss HTA depends not upon further refinement of utilities, QALYs, cost-effectiveness ratios, and simulation models, but upon replacing them with a framework founded on representational measurement, lawful quantitative inference, and prospectively evaluable, independently replicable, and falsifiable claims regarding therapy impact. For Switzerland, the failure cannot be explained by lack of access to measurement knowledge. The knowledge exists. The remaining question is whether Swiss HTA is prepared to apply it.

To facilitate this transition, Maimon Research LLC has developed a comprehensive nine-unit HTA Reconstruction Program [5]. The program provides a systematic introduction to representational measurement, the theory of attributes, the principal scales of measurement, admissible arithmetic, dimensional homogeneity, manifest and latent attributes, Rasch logit ratio measurement, protocol development, and the construction of evaluable, replicable, and falsifiable claims regarding therapy impact. Its purpose is not to modify the existing reference-case paradigm but to replace it with a scientific framework in which measurement once again precedes arithmetic.

The program has been designed for universities, HTA agencies, reimbursement organizations, research centers, professional societies, pharmaceutical companies, and health economists seeking a transition from assumption-driven modelling to scientifically defensible measurement. It provides a structured pathway for professional development while establishing the competencies required for the next generation of HTA practitioners. In this way, it offers not simply a critique of the existing paradigm but a practical route toward the reconstruction of HTA as a measurement-based scientific discipline.

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