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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

REPRESENTATIONAL MEASUREMENT FAILURE IN HEALTH TECHNOLGY ASSESSMENT

FINLAND: THE ENDORSEMENT OF CURRICULUM INVERSION

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ABSTRACT

This study examines the Finnish health technology assessment (HTA) curriculum knowledge base as a companion to an earlier interrogation of the Finnish HTA knowledge base that demonstrated a consistent pattern of measurement inversion. That investigation found that the accepted principles of representational measurement received little recognition, while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, patient-reported outcomes, and reference-case modelling were accepted as though they provided scientifically valid measures of therapy impact. The present study addresses the complementary question of how this methodological framework is created, transmitted, and sustained through the educational system responsible for preparing successive generations of Finnish HTA practitioners. The central hypothesis is that measurement inversion is reproduced through curriculum inversion.

The curriculum knowledge base was interrogated using ten canonical statements derived from the axioms of representational measurement. These statements encompass specification of the target attribute, scales of measurement, representational measurement, unidimensionality, manifest and latent attributes, ratio measurement, and the requirement that scientific claims be prospectively evaluable, independently replicable, and empirically falsifiable. Across all ten statements, endorsement probabilities remain uniformly low, indicating that the scientific principles governing lawful quantitative measurement occupy only a peripheral position within Finnish HTA education. While modest recognition is given to observable outcomes and empirical investigation, little attention is directed to representational measurement, admissible arithmetic, the distinction between manifest and latent attributes, or Rasch measurement as the required framework for measuring latent therapy outcomes.

The interrogation demonstrates that Finnish HTA education introduces students to evidence synthesis, economic evaluation, utilities, QALYs, patient-reported outcomes, and decision-analytic modelling before introducing the measurement principles required to determine whether these methods support lawful quantitative claims. Arithmetic consequently precedes measurement, and methodological convention replaces scientific validation. Curriculum inversion therefore emerges as the educational mechanism through which measurement inversion is institutionalized and reproduced across successive generations of researchers, practitioners, and policy makers.

The study concludes that incremental refinement of existing HTA methodology cannot resolve this problem because the failure lies beneath the methodology itself, in the absence of lawful measurement. Reconstruction of Finnish HTA requires a curriculum founded upon representational measurement, explicit distinction between manifest and latent attributes, linear ratio and Rasch logit ratio measurement, and prospective protocols supporting evaluable, replicable, and falsifiable claims regarding therapy impact. Only by restoring measurement as the prerequisite for arithmetic can Finnish HTA be re-established as a scientifically defensible discipline.

INTRODUCTION

The present analysis complements an earlier interrogation of the Finnish health technology assessment (HTA) knowledge base that examined the extent to which the accepted principles of representational measurement are recognized within contemporary [1] . Finnish HTA. That investigation demonstrated a consistent pattern of measurement inversion. Representational measurement, the distinction between manifest and latent attributes, lawful ratio measurement, and the scientific conditions required for quantitative claims received little recognition, while utilities, quality-adjusted life years (QALYs), cost-effectiveness analysis, patient-reported outcomes, and reference-case modelling were accepted as though they provided scientifically valid measures of therapy impact. The present study addresses the complementary question of how this methodological framework is created, transmitted, and sustained through the educational system responsible for preparing successive generations of Finnish HTA practitioners. It asks whether measurement inversion is accompanied by curriculum inversion.

The Finnish curriculum knowledge base is interrogated through the application of a standardized representational measurement framework comprising ten canonical curriculum statements derived from the axioms of representational measurement. These statements encompass specification of the target attribute, the principal scales of measurement, representational measurement, unidimensionality, the distinction between manifest and latent attributes, the corresponding requirements for linear and Rasch logit ratio measurement, and the requirement that scientific claims be prospectively evaluable, independently replicable, and empirically falsifiable. Together they provide a consistent framework for determining whether Finnish HTA education is grounded in the scientific principles that must precede quantitative analysis. The interrogation is directed not at individual universities, teaching programs, or researchers, but at the curriculum knowledge base as a whole and the concepts that students and practitioners are most likely to encounter during their professional education.

The purpose of the interrogation is therefore to determine whether Finnish HTA education introduces students first to the principles governing scientific measurement before presenting the established analytical methods of contemporary HTA. If these foundational concepts receive consistently weak endorsement while utilities, QALYs, patient-reported outcomes, cost-effectiveness analysis, and decision-analytic modelling remain the dominant components of the curriculum, the conclusion is curriculum inversion. In such a curriculum, arithmetic precedes measurement rather than following it, and methodological convention replaces scientific validation. The Finnish curriculum interrogation therefore provides the educational complement to the earlier measurement inversion study, identifying the mechanism through which the contemporary HTA paradigm is reproduced and sustained. Together, the two interrogations demonstrate not only that measurement inversion characterizes Finnish HTA practice, but also that curriculum inversion is the educational process by which that pattern is perpetuated across successive generations of researchers, practitioners, and policy makers.

CURRICULUM INVERSION

Curriculum inversion occurs when a curriculum teaches the application of quantitative methods while failing to teach the measurement principles that determine whether those methods are scientifically legitimate. In a scientifically coherent curriculum, measurement precedes arithmetic. Students first learn the nature of attributes, the requirements of representational measurement, the distinctions among nominal, ordinal, interval and ratio scales, and the conditions necessary for valid quantitative claims for manifest and the application of Rasch models for latent attributes [2] [3] [4] . Only then are they introduced to the arithmetic, statistical and modelling procedures that depend upon those measurement properties. Curriculum inversion reverses this sequence. Students learn how to calculate, model and analyze before they learn how to determine whether the quantities entering those analyses are measures. Arithmetic becomes detached from measurement and numerical manipulation is treated as though it were equivalent to quantitative science.

The consequences are profound. A curriculum affected by inversion reproduces a professional culture in which measurement is assumed rather than demonstrated. Concepts such as unidimensionality, dimensional homogeneity, admissible arithmetic, manifest and latent attributes, ratio measurement and Rasch measurement either disappear entirely or are treated as peripheral concerns. Students become proficient in the techniques of economic evaluation, utility assessment, QALY construction and simulation modelling without acquiring the conceptual tools necessary to evaluate the legitimacy of those methods. The result is that the curriculum not only fails to identify measurement errors but actively reproduces them across successive generations of researchers, analysts and decision makers. Curriculum inversion therefore serves as the educational mechanism through which measurement inversion becomes institutionalized within a discipline. In HTA this serves to support administrative decisions for therapy pricing and access.

For this reason, curriculum assessment emerges as a critical component of HTA reconstruction. The objective is not simply to determine whether students are exposed to contemporary HTA methods. Rather, it is to determine whether they are exposed to the foundational concepts that make the evaluation of those methods possible. A curriculum that emphasizes modelling, economic evaluation and decision analysis while neglecting measurement theory will inevitably reproduce the same conceptual limitations observed in current HTA practice.

The curriculum interrogations compelling support for this interpretation. While there is evidence that students and researchers are introduced to outcomes assessment, target attributes and scientific claims, there is little evidence of systematic exposure to scales of measurement, the axioms of representational measurement, unidimensionality, latent attribute measurement or ratio measurement. The concepts most frequently absent from curriculum coverage are precisely those concepts most frequently absent from HTA practice. The relationship is unlikely to be coincidental.

The imperative of measurement inversion therefore extends beyond criticism of existing methods. It points directly to the need for educational reconstruction. If HTA is to move toward a framework based on lawful measurement, evaluable claims and empirical falsification, then curriculum reform must accompany methodological reform. The widespread and consistent pattern of measurement inversion revealed by the interrogations suggests that reconstruction cannot begin with policy guidance or analytical techniques alone. It must begin with the curriculum. Until students and researchers are introduced to the foundations of measurement science, the conditions that created measurement inversion will continue to be reproduced throughout the HTA community.

THE FINNISH HTA CURRICULUM KNOWLEDGE BASE

The Finnish health technology assessment (HTA) curriculum knowledge base comprises the educational, methodological, and professional resources through which the principles and practice of HTA are taught, interpreted, and disseminated throughout Finland. It extends well beyond formal university degree programs to include postgraduate education, continuing professional development, methodological guidance issued by national health authorities, publications from academic research centers, professional societies, conference proceedings, textbooks, and the extensive literature in health economics, clinical epidemiology, outcomes research, evidence-based medicine, and health services research. Collectively, these resources establish the conceptual framework through which successive generations of physicians, pharmacists, economists, epidemiologists, policy analysts, healthcare managers, researchers, consultants, and government officials acquire their understanding of HTA and its role in informing decisions regarding the adoption, reimbursement, pricing, and evaluation of health technologies.

Finland occupies an important position within Nordic health technology assessment and has made substantial contributions to evidence-based medicine, comparative effectiveness research, clinical epidemiology, registry-based research, health economics, and health services evaluation. Finnish universities, government agencies, and research institutes have been active participants in the development of HTA methodology both nationally and through European collaborations. Research on patient-reported outcomes, economic evaluation, healthcare utilization, and resource allocation has contributed to the broader international HTA literature, while Finnish participation in European HTA initiatives has helped shape methodological standards adopted throughout the region. Consequently, the Finnish curriculum knowledge base is important not only because it prepares professionals within Finland but because it contributes to the wider European framework through which HTA methodology is taught, interpreted, and applied.

The purpose of identifying the Finnish curriculum knowledge base is to distinguish the educational framework through which HTA concepts are transmitted from the broader Finnish HTA knowledge base that encompasses assessment reports, reimbursement recommendations, methodological guidance, clinical practice recommendations, and healthcare policy implementation. Nested within this broader body of knowledge is an educational system whose principal purpose is to transmit accepted analytical methods and professional assumptions to future practitioners. It determines which concepts are regarded as fundamental, the sequence in which they are introduced, the analytical techniques considered appropriate, and the standards by which professional competence is judged. The present interrogation is directed toward this educational framework rather than toward the conclusions reached in individual HTA reports or reimbursement decisions.

The central question addressed by this interrogation is whether Finnish HTA education introduces students and practitioners first to the scientific principles governing measurement before presenting the accepted analytical methods of contemporary HTA. These principles include specification of the target attribute, the principal scales of measurement, the axioms of representational measurement, admissible arithmetic, dimensional homogeneity, unidimensionality, the distinction between manifest and latent attributes, the corresponding requirements for linear ratio and Rasch logit ratio measurement, and the requirement that quantitative claims be prospectively evaluable, independently replicable, and capable of empirical falsification. These concepts are not optional methodological refinements but the scientific foundations upon which every lawful quantitative claim ultimately depends.

The importance of examining the Finnish curriculum knowledge base therefore extends well beyond national educational practice. If these scientific foundations are absent from the educational system responsible for preparing Finnish HTA practitioners, researchers, and policy analysts, the implications extend directly to the future development of HTA in Finland. Curriculum inversion would indicate that students are introduced to utilities, quality-adjusted life years (QALYs), patient-reported outcomes, cost-effectiveness analysis, and decision-analytic modelling before they are taught the principles of measurement required to determine whether those methods are scientifically legitimate. The Finnish curriculum interrogation therefore seeks to establish whether HTA education is grounded in the accepted principles of representational measurement or whether it instead reproduces methodological convention without first establishing the conditions required for lawful quantitative measurement. The answer provides an important indication of whether Finland is preparing future HTA practitioners to undertake measurement-based scientific evaluation or to perpetuate the existing paradigm of measurement inversion.

INTERROGATING THE FINNISH CURRICULUM KNOWLEDGE BASE

The objective of large language model (LLM) curriculum interrogation differs from that of previous HTA knowledge-based practice assessments. Earlier interrogations focused on whether institutions recognized the requirements of representational measurement and the standards necessary for quantitative claims. Curriculum interrogation asks a different question. Are faculty, students and researchers exposed to the concepts necessary to understand and apply those standards? The focus shifts from methodological outputs to educational inputs. Rather than examining what faculty, students and researchers do, attention is directed to what they are taught and what they know.

The importance of this distinction should not be underestimated. Educational programs do not merely transmit technical skills. They define the conceptual framework through which future practitioners understand evidence, measurement and scientific inquiry. Concepts that are absent from the curriculum are unlikely to emerge spontaneously in research practice. Equally, concepts that are emphasized repeatedly become part of the intellectual assumptions that shape subsequent analysis have never been systematically incorporated into HTA teaching and research training.

For this reason, the curriculum interrogation was designed around a series of canonical statements intended to identify the presence or absence of foundational measurement concepts. These statements were deliberately elementary. The purpose was not to assess advanced methodological knowledge but to determine whether faculty, students and researchers are likely to encounter the principles that underpin lawful quantitative claims. The resulting framework begins with the concept of an attribute as the object of measurement and proceeds through target attribute specification, scales of measurement, representational measurement, unidimensionality, manifest and latent attributes, ratio measurement and falsifiable claims. Together, these statements define the minimum intellectual foundations required for a measurement-based approach to therapy assessment in education.

These statements are:

- **An attribute is the specific outcome of interest in a therapy assessment.**
- **Every therapy assessment begins with specification of the target attribute.**
- **The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis.**
- **The measurement status of a target attribute must be established before quantitative claims can be advanced.**
- **The axioms of representational measurement underpin quantitative claims.**
- **Attributes must be demonstrated to be unidimensional before measurement is possible.**
- **A manifest attribute is directly observable and capable of supporting empirical observation.**
- **A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute.**
- **Manifest and latent attributes require different forms of ratio measurement.**
- **Therapy impact claims must be falsifiable.**

These ten statements form a logical sequence:

Attribute → Target Attribute → Scales of Measurement → Measurement Status → Representational Measurement → Unidimensionality → Manifest Attribute → Latent Attribute → Ratio Measurement → Falsifiable Claims

The categorical probabilities reported in this assessment are intended as indicators of the extent to which a concept is represented within the curriculum knowledge base. They should not be interpreted as precise statistical estimates but as measures of the likelihood that a student, researcher or professional exposed to that knowledge base would encounter, recognize and subsequently endorse the canonical statement. In practical terms, the probability reflects the visibility and prominence of a concept within the educational environment associated with a research center or policy agency.

A high probability indicates that the concept is well represented within curriculum materials, research outputs and educational activities and is therefore likely to be familiar to students and researchers. Conversely, a low probability suggests that the concept is absent, only weakly represented, or occupies a peripheral position within the curriculum knowledge base. Students exposed to such an environment would therefore be unlikely to recognize the concept as an important component of HTA education and practice.

The probabilities should be viewed comparatively rather than in isolation. Their principal value lies in identifying patterns of curriculum coverage across institutions and concepts. In particular, low probabilities associated with scales of measurement, representational measurement, unidimensionality and ratio measurement indicate that these topics are unlikely to form a substantial part of the educational experience of the average student. The resulting profile provides an indication of curriculum strengths, deficiencies and potential areas for reconstruction.

FINLAND AND CURRICULUM INVERSION

The interrogation of the Finnish health technology assessment (HTA) curriculum knowledge base demonstrates consistently weak endorsement of the scientific principles required for lawful quantitative measurement (Table 1). Across the ten canonical curriculum statements, endorsement probabilities range from only 0.05 to 0.25, with no concept receiving moderate or strong support. The resulting profile indicates that while Finnish HTA education provides some recognition of observable outcomes and empirical investigation, the concepts required to establish lawful quantitative measurement occupy only a peripheral position within the curriculum.

The strongest endorsement is assigned to the statement that a manifest attribute is directly observable and capable of supporting empirical observation (probability 0.25). This is followed by recognition that an attribute is the specific outcome of interest in a therapy assessment, that the principal scales of measurement possess different mathematical properties, and that therapy-impact claims should be falsifiable (probability 0.20). These findings suggest that Finnish HTA education retains elements of a conventional scientific framework but does not extend that framework to the measurement conditions required for quantitative inference.

Recognition becomes substantially weaker for the principles that distinguish measurement from numerical analysis. Specification of the target attribute and the requirement that attributes be demonstrated to be unidimensional each receive probabilities of only 0.15. Even weaker endorsement is observed for establishing measurement status before quantitative claims can be advanced and for recognizing that latent attributes require explicit measurement models, both receiving probabilities of 0.10. These findings indicate that students are unlikely to acquire the conceptual framework necessary to determine whether a numerical quantity constitutes a lawful measure or merely a score

The weakest endorsement concerns the axioms of representational measurement and the principle that manifest and latent attributes require different forms of ratio measurement. Both receive probabilities of only 0.05. This is the critical finding because these principles underpin every quantitative discipline. Without representational measurement there is no scientific basis for determining whether empirical observations have been mapped into numerical relations capable of supporting arithmetic. Without distinguishing manifest from latent attributes there is no coherent basis for determining whether observable outcomes require linear ratio measurement or latent outcomes require Rasch logit ratio measurement.

TABLE 1: CURRICULUM CONTENT ENDORSEMENT: FINNISH KNOWLEDGE BASE

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	0.20	-1.40
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	0.15	-1.75
A manifest attribute is directly observable and capable of supporting empirical observation	0.25	-1.25
A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute	0.10	-2.20
Manifest and latent attributes require different forms of ratio measurement	0.05	-2.50
Therapy impact claims must be falsifiable	0.20	-1.40

.Taken together, these findings demonstrate that the Finnish HTA curriculum exhibits the defining characteristics of curriculum inversion. Students are introduced to evidence synthesis, health economics, utilities, quality-adjusted life years (QALYs), patient-reported outcomes, cost-effectiveness analysis and decision-analytic modelling before they are introduced to the scientific principles governing measurement itself. Arithmetic consequently precedes measurement, and methodological convention replaces scientific validation. Finland therefore joins the growing list of countries in which HTA education reproduces measurement inversion by omitting the foundational concepts upon which lawful quantitative evaluation depends.

STATEMENT-BY-STATEMENT REVIEW

Statement 1: An attribute is the specific outcome of interest in a therapy assessment
Probability 0.20; Normalized Logit –1.40

Recognition of the concept of an attribute is limited. Although Finnish HTA education routinely considers clinical outcomes, patient-reported outcomes, and measures of healthcare utilization, these are not consistently introduced as formally specified attributes that must be defined before measurement begins. Consequently, attention often shifts directly to available outcome measures, utilities, or economic models without first establishing precisely what characteristic is to be measured. This weakens the scientific foundation of subsequent quantitative claims.

Statement 2: Every therapy assessment begins with specification of the target attribute
Probability 0.15; Normalized Logit –1.75

This principle receives only weak endorsement. The curriculum suggests that assessments commonly begin with established HTA methodologies, available evidence, or economic evaluation rather than with explicit specification of the target attribute. The scientifically appropriate sequence is thereby reversed. Instead of defining the attribute before selecting the method of measurement, the available analytical framework frequently determines the attribute that is ultimately evaluated.

Statement 3: The principal scales of measurement (nominal, ordinal, interval and ratio) have different properties and support different forms of analysis
Probability 0.20; Normalized Logit –1.40

There is limited recognition that different measurement scales possess different mathematical properties. Although the terminology of nominal, ordinal, interval and ratio scales may appear within research methods or statistics teaching, there is little evidence that these distinctions become organizing principles within Finnish HTA education. Consequently, students are unlikely to appreciate that arithmetic operations depend upon the measurement properties of the underlying data.

Statement 4: The measurement status of a target attribute must be established before quantitative claims can be advanced
Probability 0.10; Normalized Logit –2.20

This statement receives very weak endorsement. Establishing measurement status is the essential prerequisite for quantitative science because arithmetic cannot legitimately precede measurement. The interrogation suggests that Finnish HTA education generally assumes that existing clinical outcomes, utility measures, and patient-reported scores possess appropriate measurement properties without requiring independent demonstration.

Statement 5: The axioms of representational measurement underpin quantitative claims
Probability 0.05; Normalized Logit –2.50

This is one of the weakest endorsed statements within the interrogation. The mathematical principles governing representational measurement receive almost no explicit recognition within the Finnish curriculum knowledge base. Students are therefore unlikely to encounter the scientific foundations that determine whether empirical observations constitute lawful measures capable of supporting quantitative inference. Their absence leaves quantitative HTA without its essential measurement framework.

Statement 6: Attributes must be demonstrated to be unidimensional before measurement is possible
Probability 0.15; Normalized Logit –1.75

Recognition of unidimensionality is limited. Finnish HTA education provides little indication that students are expected to establish whether an attribute represents a single measurable construct before quantitative analysis proceeds. Composite indices and multidimensional instruments can therefore be accepted without demonstrating that they satisfy one of the fundamental conditions for scientific measurement.

Statement 7: A manifest attribute is directly observable and capable of supporting empirical observation
Probability 0.25; Normalized Logit –1.10

This statement receives the strongest endorsement within the interrogation, although the probability remains modest. There is some recognition that observable clinical outcomes differ from more abstract concepts. However, this understanding is not developed into a comprehensive measurement framework that distinguishes the measurement requirements of observable and non-observable attributes. Recognition of manifest attributes therefore remains descriptive rather than methodological.

Statement 8: A latent attribute is not directly observable and requires a measurement model to estimate possession of the attribute
Probability 0.10; Normalized Logit –2.20

Recognition of latent measurement is weak. Although Finnish HTA makes extensive use of patient-reported outcomes and quality-of-life instruments, there is little evidence that the curriculum systematically introduces the measurement models required to estimate possession of latent attributes. Instead, aggregated scores and utility values appear to be accepted as though they themselves constitute valid measures.

Statement 9: Manifest and latent attributes require different forms of ratio measurement
Probability 0.05; Normalized Logit –2.50

This statement receives the lowest level of endorsement. The curriculum demonstrates little appreciation that manifest attributes require linear ratio measurement whereas latent attributes require Rasch logit ratio measurement. The absence of this distinction contributes directly to the routine treatment of utilities, preference scores, and composite indices as though they possessed equivalent measurement status. This represents one of the clearest indicators of curriculum inversion.

Statement 10: Therapy impact claims must be falsifiable
Probability 0.20; Normalized Logit –1.40

Recognition that therapy impact claims should be capable of empirical falsification is limited. While Finnish HTA places considerable emphasis on evidence synthesis, systematic reviews, and economic evaluation, comparatively little attention is given to the prospective specification of evaluable, independently replicable and falsifiable claims. Consequently, many quantitative conclusions depend more upon accepted modelling conventions than upon direct empirical testing of scientifically measurable therapy outcomes.

MANIFEST AND LATENT ATTRIBUTES: THE MISSING FOUNDATION OF FINNISH HTA

A central finding of the Finnish 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 principles 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 employed within HTA is scientifically admissible. The distinction establishes the entire logic of measurement and determines the appropriate quantitative framework for evaluating therapy impact.

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 represent observable phenomena that can be counted, timed, or otherwise recorded directly. When properly specified they support linear ratio measures possessing a meaningful zero and therefore permit lawful arithmetic operations. The scientific task is straightforward: define the attribute, specify the unit of observation, determine the observation period, and subject the resulting claim to empirical evaluation, independent replication, and potential falsification.

Latent attributes present an entirely different measurement problem. Pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, health confidence, and need fulfilment cannot be observed directly. Their existence must instead be inferred from observable indicators, most commonly 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 mathematical properties necessary for lawful quantitative inference. Without such a model, ordinal observations remain ordinal observations irrespective of the sophistication of subsequent statistical analysis.

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. Failure to recognize this distinction inevitably leads to inappropriate treatment of fundamentally different forms of evidence as though they possessed equivalent measurement status.

The interrogation indicates that the Finnish curriculum knowledge base does not recognize this distinction as an organizing principle for HTA education. Instead, outcomes are grouped within broad methodological categories such as patient-reported outcomes, quality of life, utility measurement, clinical effectiveness, evidence synthesis, and economic evaluation. Although useful for administrative and descriptive purposes, these categories are scientifically inadequate because they fail to distinguish directly observable attributes from latent attributes requiring a formal measurement model. The measurement requirements governing each type of outcome therefore remain obscured.

Once this distinction disappears, almost any numerical output can be treated as though it possesses equivalent quantitative status. Utility scores, preference weights, composite indices, symptom scales, observational counts, registry-derived outcomes, and resource-use measures become incorporated within a common analytical framework despite possessing fundamentally different measurement properties. The result is a progressive erosion of measurement discipline in which numerical construction is mistaken for quantitative measurement and arithmetic replaces measurement as the foundation of scientific inference.

For Finland this finding has particular significance. Finnish universities, research institutes, and national health authorities have established an international reputation for evidence-based medicine, clinical epidemiology, population registers, health services research, health economics, and health technology assessment. Finnish methodological contributions have strengthened Nordic and European HTA, particularly through advances in observational research, registry-based evaluation, and economic assessment. The curriculum interrogation indicates, however, that the educational framework supporting these achievements does not begin with the fundamental distinction required by representational measurement. Successive generations of practitioners therefore become proficient in evidence synthesis, health economic evaluation, cost-utility analysis, and decision modelling without first addressing the elementary scientific question that should precede every quantitative assessment: what type of attribute is being measured, and what form of measurement is scientifically required? Until the distinction between manifest and latent attributes becomes the organizing principle of Finnish HTA education, curriculum inversion will continue to reproduce measurement inversion, limiting the scientific foundations upon which quantitative claims regarding therapy impact are constructed.

THE ABSENCE OF RASCH

The absence of the manifest-latent distinction also explains the near absence of Rasch measurement within the Finnish curriculum knowledge base. If latent attributes are not explicitly recognized as requiring a measurement model, there is no perceived need to introduce the one measurement framework capable of constructing lawful quantitative measures of latent attribute possession. Instead, ordinal questionnaire responses are transformed into utility scores, composite indices, and quality-adjusted life years (QALYs) and subsequently treated as though measurement has already been achieved. The measurement problem is therefore bypassed rather than solved.

From the perspective of curriculum design, this represents a classic example of curriculum inversion. Students are introduced to utilities, QALYs, patient-reported outcomes, health economic evaluation, and reference-case modelling before they are taught to distinguish between manifest and latent attributes. Consequently, they are never encouraged to ask the fundamental scientific question that should precede every HTA assessment: What is the target attribute, is it manifest or latent, and which lawful form of ratio measurement is required?

For Finland this omission is particularly significant because health technology assessment plays an increasingly important role in decisions concerning the adoption, reimbursement, pricing, and evaluation of pharmaceuticals, medical devices, diagnostics, and healthcare interventions within a publicly funded healthcare system. The interrogation suggests that the Finnish curriculum knowledge base has adopted the methodological conventions of contemporary HTA without first establishing the scientific foundations of measurement. Until the distinction between manifest and latent attributes becomes the organizing principle of Finnish HTA education, curriculum inversion will continue to reproduce measurement inversion throughout Finnish teaching, research, and policy evaluation.

One of the most striking findings from the interrogation of the Finnish HTA curriculum knowledge base is not simply the absence of representational measurement but the near-complete absence of Rasch measurement and its role in the assessment of latent attributes. This omission is particularly significant because Finland has established an international reputation for evidence-based medicine, clinical epidemiology, population register research, health services research, health economics, and health technology assessment. Finnish researchers have contributed substantially to Nordic and European HTA, particularly in the use of registry data, comparative effectiveness research, and economic evaluation. Yet the educational framework underpinning these activities gives little recognition to the one measurement framework capable of constructing lawful quantitative measures of latent attributes. The issue is not whether the term *Rasch* occasionally appears within specialist psychometric publications or methodological research. The issue is whether Rasch measurement is recognized as the scientific foundation for measuring latent therapy outcomes. The interrogation indicates that it is not.

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

The distinction is fundamental. Patient-reported outcomes begin with ordinal responses to questionnaire items describing pain, fatigue, depression, anxiety, physical functioning, treatment satisfaction, need fulfilment, and other latent attributes. These responses provide information about order but not quantity. Arithmetic performed directly on ordinal observations cannot create measurement. Summed scores, averages, weighted algorithms, utility values, and preference functions remain numerical constructions unless it has first been demonstrated that the underlying latent attribute has been measured. Numerical manipulation is not measurement.

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

The interrogation indicates that this perspective is largely absent from the Finnish curriculum knowledge base. Students and practitioners are introduced to patient-reported outcomes, utilities, quality-of-life instruments, preference weights, QALYs, and economic evaluation without first confronting the measurement problem these constructs are intended to solve. The educational sequence moves directly from ordinal responses to scoring systems and economic models. The essential intermediate step demonstrating that a latent attribute has been measured is effectively bypassed.

This omission has profound implications. Without Rasch measurement, latent attributes remain unmeasured. Utility scores, composite indices, and preference algorithms may generate numerical outputs, but they do not establish that the underlying construct has been measured. The existence of a number should never be confused with the existence of a measure. Nevertheless, much of contemporary Finnish HTA proceeds as though this distinction does not exist. Students consequently learn how utilities are generated, how QALYs are constructed, and how reference-case models are populated, yet they are not taught how latent attributes themselves can be measured. The curriculum therefore introduces numerical representations of patient benefit before introducing the scientific framework required to justify those representations. This is curriculum inversion in its clearest form.

For Finland the implications are direct. A healthcare system internationally recognized for its commitment to evidence-based healthcare, comprehensive population registers, and rigorous health services research should equally require that the quantities informing reimbursement and policy decisions satisfy the accepted standards of representational measurement. Until Rasch measurement assumes its proper place within Finnish HTA education, latent attributes will continue to be represented through scores, utilities, and indices rather than lawful measures, and the distinction between scoring and measurement will remain obscured. Curriculum inversion will therefore continue to reinforce the broader pattern of measurement inversion that characterizes contemporary HTA, limiting the scientific legitimacy of quantitative claims regarding therapy impact.

CONCLUSION: CURRICULUM INVERSION AND THE FUTURE OF HTA IN FINLAND

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

The interrogation demonstrates that the Finnish 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 economic evaluation, utilities, QALYs, decision modelling, evidence synthesis, patient-reported outcomes, and reimbursement methodology rather than upon specification of the target attribute, representational measurement, admissible arithmetic, unidimensionality, manifest and latent attributes, Rasch measurement, dimensional homogeneity, and the requirement that therapy-impact claims be prospectively evaluable, independently replicable, and capable of falsification. Graduates therefore acquire technical competence in constructing the contemporary HTA framework without first acquiring the scientific framework necessary to determine whether that framework supports lawful quantitative claims.

For Finland this conclusion has important implications. Finnish universities, research institutes, and national health authorities have earned an international reputation for evidence-based medicine, clinical epidemiology, population register research, health services research, health economics, and health technology assessment. Finnish methodological contributions have strengthened both Nordic and European HTA, particularly through advances in comparative effectiveness research, registry-based evaluation, and economic analysis. The interrogation indicates, however, that the educational framework supporting contemporary HTA has adopted the analytical conventions of the international reference-case paradigm without first embedding the scientific principles of representational measurement. The consequence is that curriculum inversion has become the mechanism through which measurement inversion is reproduced within Finnish HTA. Utilities, QALYs, cost-effectiveness ratios, and reference-case simulation models continue to occupy a central position in professional education despite depending upon quantities that fail the accepted requirements for lawful measurement.

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, more sophisticated utility instruments, increasingly complex statistical analyses, expanded real-world evidence, richer national register data, or progressively more elaborate simulation techniques. None of these developments can create measurement where measurement does not exist. Arithmetic cannot rescue quantities that are not measures. Decades of methodological refinement have failed to resolve this problem because the problem lies beneath the methodology itself—in the absence of lawful measurement.

The implications for Finnish universities are therefore direct. Continuing to educate students in the construction and application of reference-case models without first teaching the scientific principles governing lawful measurement is incompatible with the central purpose of higher education. Universities exist to advance objective knowledge rather than perpetuate analytical traditions whose measurement foundations cannot support quantitative claims. Students should certainly understand the historical importance of utilities, QALYs, patient-reported outcome instruments, and reference-case modelling, but they should understand them as examples of a paradigm that failed to satisfy the accepted standards governing quantitative science. They should not be taught that these constructs provide valid measures of therapy impact because they do not.

The only scientifically defensible path forward is reconstruction. Every HTA submission 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 Finnish HTA has reached its intellectual limit. It has undoubtedly strengthened evidence synthesis, promoted rigorous use of national register data, and contributed to more consistent administrative decision making, yet it has failed to establish the scientific legitimacy of the quantities upon which those decisions ultimately depend. That framework has no scientific future because it rests upon measurement impossibilities. Its place is no longer at the center of HTA education but in the history of the discipline as an instructive example of how methodological sophistication can evolve independently of measurement science. The future of Finnish HTA therefore depends not upon refining the existing paradigm but upon replacing it with one founded upon representational measurement, lawful quantitative inference, and empirically evaluable claims regarding therapy impact.

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

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

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