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ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

THE CONTRIBUTION OF REPRESENTATIONAL MEASUREMENT

TEXAS: TOWARDS A NEW CURRICULUM IN HEALTH TECHNOLOGY ASSESSMENT

A Transition for Faculty and Students

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ABSTRACT

The accumulated evidence from measurement inversion, curriculum inversion and program-content interrogation identifies a foundational problem for health technology assessment (HTA) education in Texas: arithmetic and modelling have been allowed to precede measurement. Representational measurement is not an additional methodological topic to be placed alongside economic evaluation, statistics or decision modelling. It establishes the conditions under which quantitative operations are scientifically admissible. Scale properties constrain arithmetic, multiplication and division require ratio measurement, dimensional homogeneity must be respected, and numerical assignment does not itself create measurement. The educational challenge is therefore one of transition rather than simply adding further methodological content to established programs.

The required scientific sequence is attribute → measurement → admissible arithmetic → quantitative claim. Students should first identify the target attribute, determine whether it is manifest or latent, establish the appropriate measurement pathway and determine which arithmetic operations the resulting scale permits. Manifest attributes may support linear ratio measurement where the necessary conditions are satisfied. Latent attributes require construction of an invariant quantitative continuum, with Rasch measurement providing the required pathway. The objective is to enable students to ask what an attribute is, how it has been measured and what arithmetic that measurement permits.

For Texas universities and research centers, transition need not require immediate abandonment of established HTA teaching. Lawful measurement can initially be introduced alongside existing courses, allowing faculty and students to examine utilities, QALYs, ICERs, patient-reported outcomes and decision models against an independent measurement framework. Faculty development and student education can proceed together.

The Maimon Research nine-unit HTA transformation program provides a structured foundation for this transition, supported by continuing interaction with Maimon Research and access to more than 200 Logit Working Papers and related analyses. It can support faculty preparation, parallel faculty/student learning, reconsideration of existing courses and development of a formal graduate curriculum.

The objective is not to prescribe conclusions, but to provide Texas faculty and students with the scientific knowledge required to evaluate quantitative claims themselves. The essential transition is one of scientific ordering: measurement first, admissible arithmetic second, and quantitative HTA thereafter.

INTRODUCTION: A NEW START

The accumulated evidence from measurement inversion, curriculum inversion and program-content interrogation identifies a foundational problem in contemporary health technology assessment (HTA): arithmetic has been allowed to precede measurement. Representational measurement is not simply another methodological topic to be placed alongside economic evaluation, statistics, epidemiology or decision modelling [1] [2]. It establishes the conditions under which quantitative operations are scientifically admissible.

The implications are fundamental. Scale properties determine admissible operations; multiplication and division require ratio measurement; dimensional homogeneity must be respected; and numerical assignment does not by itself create measurement. Once these principles are recognized, the educational question is no longer whether measurement might usefully be added to an otherwise unchanged HTA curriculum. It is how graduate education should be reorganized when measurement is recognized as the necessary foundation for quantitative claims**.**

This does not require universities to dismantle established programs immediately. The challenge is one of transition: providing faculty and students with the measurement knowledge required to examine the methods they currently teach, study and use, while creating a pathway towards a measurement-based HTA curriculum.

This paper should be read alongside the Texas analyses available on the Maimon Research website, which provide the detailed evidence concerning measurement inversion, program content and their implications for HTA education and research in the state [3] [4] [5] [6]. The purpose here is different. It asks what faculty and universities can do after the measurement problem has been identified and proposes a supported pathway towards a measurement-based curriculum.

THE EDUCATION INVERSION

The conventional sequence of HTA education typically begins downstream. Students encounter health economics, utilities, QALYs, cost-effectiveness and cost-utility analysis, ICERs, decision trees, Markov models, simulation, sensitivity analysis and other quantitative techniques. They learn how numerical values are combined and how the resulting analyses are interpreted.

What is typically missing is the prior question: what are these numbers scientifically entitled to represent?

The correct scientific sequence begins with the target attribute. Its measurement requirements must first be established. The investigator must determine whether the attribute is manifest or latent, identify the appropriate measurement pathway, establish the properties of the resulting scale and determine which arithmetic operations those properties permit. Only after these requirements have been satisfied should statistical analysis, economic evaluation or modelling begin. The required sequence is therefore: attribute → measurement → admissible arithmetic → quantitative claim

Reversing this order creates curriculum inversion. Students can become proficient in manipulating numerical values without acquiring the scientific criteria required to determine whether those manipulations are admissible.

This is why the recurring 0/17 versus 20/20 findings from program-content interrogation comparing representational measurement topics and legacy HTA topics are consequential. They do not merely suggest that contemporary HTA programs devote insufficient or no attention to measurement. They indicate that the material logically required to evaluate the quantitative legitimacy of contemporary HTA is absent while the methods to which those requirements should be applied are comprehensively represented.

THE TRANSITION PROBLEM

Universities now face a practical difficulty. Faculty cannot simply be expected to begin teaching a body of measurement knowledge that may have been absent from their own graduate education. Most faculty teaching contemporary HTA, pharmacoeconomics and outcomes research were themselves trained within the established framework. They learned the methods transmitted through universities, textbooks, journals, professional organizations, guidelines and accepted research practice.

This helps explain how educational inversion could be reproduced across successive generations. It also identifies where transition must begin. Faculty development and student education have to proceed together.

The immediate requirement is not that faculty abandon existing teaching or accept every implication of the measurement critique. It is that faculty and students acquire sufficient knowledge of representational measurement to examine the established framework themselves.

This creates an important transitional opportunity. Lawful measurement can initially be introduced alongside existing HTA teaching. Existing courses can continue while faculty and students acquire an independent scientific framework against which their quantitative methods and claims can be evaluated. The university is therefore not required to make an immediate commitment to wholesale curriculum reconstruction before faculty and students have had an opportunity to understand the measurement issues involved.

This parallel approach is deliberately non-prescriptive about the conclusion. Faculty who believe that utilities support multiplication by time, that QALYs constitute legitimate quantitative measures and that cost-per-QALY ICERs are scientifically meaningful ratios remain free to defend those propositions. Students, however, should possess the measurement principles necessary to determine whether those propositions can be sustained.

The purpose of the transition is therefore not to prescribe belief. It is to provide the missing scientific knowledge required for critical evaluation.

RATIO MEASUREMENT AS THE FOUNDATION

Ratio measurement occupies a central position in this transition because multiplication, division and meaningful ratios cannot legitimately be performed simply because observations have been assigned numerical values

Students need to understand why equal units and a non-arbitrary zero matter, why admissible transformations constrain arithmetic and why dimensional homogeneity is a condition of legitimate quantitative analysis. These are not abstract issues detached from HTA. They determine whether many of the quantitative operations encountered in economic evaluation and therapy assessment are admissible.

The educational task, however, goes beyond teaching the conventional hierarchy of nominal, ordinal, interval and ratio scales. Students must learn to begin with the attribute. This immediately introduces the distinction between manifest and latent attributes and the different measurement requirements associated with each.

Manifest attributes such as survival time, hospital days, treatment administrations and other directly observable quantities may support linear ratio measurement where the necessary conditions are satisfied. Their measurement depends upon establishing appropriate units and a non-arbitrary zero so that the resulting quantities support the arithmetic required by the proposed claim.

Latent attributes such as pain, fatigue, physical function or need fulfilment present a fundamentally different measurement problem. They cannot simply be assigned numbers through questionnaires and assumed to have become measures. An appropriate measurement model is required to construct a quantitative continuum and establish possession of the target attribute. Rasch measurement provides the pathway for constructing such measures [7]..

The objective is therefore not to teach students a collection of disconnected measurement techniques, but to change the scientific ordering of quantitative inquiry. The student learns to ask first: what attribute is being measured, how has it been measured, and what arithmetic does that measurement permit?

For universities, the attraction of a transitional approach is that adoption need not initially require wholesale restructuring. A department can introduce lawful measurement alongside an existing HTA, health-economics, pharmacoeconomics or outcomes-research program. Faculty can study the measurement framework while students encounter it as a parallel foundation for examining the methods already being taught. This provides a low-disruption entry into curriculum transition.

The initial objective is measurement literacy. Faculty and students should understand why scale properties matter, why multiplication and division require ratio measurement, why manifest and latent attributes require different measurement pathways, and why quantitative claims must ultimately be capable of empirical evaluation, replication and falsification.

Once these principles are understood, they cannot readily be confined to a measurement module and forgotten. Students can apply them throughout their education. They can ask whether a utility possesses the properties required for multiplication by time, whether a QALY constitutes a legitimate quantitative measure, whether an ICER has a defensible denominator, whether a patient-reported score is a measure, and whether the numerical inputs entering a model support the operations performed upon them.

The university does not therefore have to prescribe the conclusions in advance. It has to provide the scientific framework within which those conclusions can be examined.

A NINE-UNIT FOUNDATION FOR TRANSITION

It is precisely this educational gap that the Maimon Research nine-unit HTA transformation program is intended to address [8]. The program provides a structured foundation for faculty, researchers and graduate students seeking to understand and apply a transition from legacy HTA to quantitative evaluation grounded in representational measurement.

The nine units move progressively through the foundations required for this transition, including attributes, measurement scales, admissible arithmetic, ratio measurement, manifest and latent attributes, measurement of latent attributes, possession, manifest measurement and the construction of empirically evaluable therapy-impact claims.

The purpose of identifying these areas here is not to reproduce the instructional program. Knowing the principles and developing the capability to apply them are different educational tasks**.** The program provides the structured instruction through which participants can move from recognition of the measurement problem to practical competence in a measurement-based framework.

The program can initially support individual faculty preparation or parallel faculty/student learning while established HTA teaching continues. It can subsequently support reconsideration of existing courses and, where a university wishes to proceed further, provide the instructional foundation for development of a formal three-credit graduate course in measurement-based HTA.

FACULTY AND STUDENTS

Faculty necessarily have a leading role in curriculum transition, but faculty development and student education need not occur sequentially. A parallel program allows both to learn.

This is important because many faculty members were themselves educated within the established legacy HTA framework. They should not be expected to reconstruct a measurement-based curriculum unaided. The program provides a framework against which existing courses, instruments, research practices and quantitative claims can be reconsidered.

Students bring a different perspective. If provided with measurement principles early in their graduate education, they can apply them directly to everything that follows. The result is therefore not simply another course or body of instructional material. It is the beginning of an internal measurement capability within the university.

A SUPPORTED TRANSITION

The nine-unit program is not intended to be a collection of materials purchased and then studied in isolation. Transition from legacy HTA to lawful measurement raises questions that cannot always be anticipated in advance, particularly when participants begin applying measurement principles to existing teaching and research.

Participants therefore have continuing online access to Maimon Research for questions and discussion arising from the program**.** Questions may concern attributes, scale properties, admissible arithmetic, ratio measurement, dimensional homogeneity, Rasch measurement, attribute possession, therapy-impact claims, protocols or the implications of these principles for particular courses and research programs. The objective is not simply to explain the written material, but to help participants develop the capability to apply the framework independently.

This interaction becomes particularly important when faculty begin considering curriculum change. Questions may arise over where measurement should enter an existing program, which subjects require reconsideration, how manifest and latent measurement should be introduced, and how students should progress from attributes and measurement to admissible arithmetic and evaluable claims. Maimon Research can work with participating faculty as these issues emerge and assist in adapting the nine-unit foundation to the requirements of an individual university or program.

Institutional engagement can develop incrementally. Individual participation may lead to discussions among colleagues, seminars, faculty workshops or small-group sessions and, eventually, curriculum development. This allows transition to proceed at a pace appropriate to the institution rather than requiring a complete replacement curriculum at the outset.

BEYOND THE NINE UNITS

The nine-unit program is supported by the broader body of material available through the Maimon Research website. The collection of over 200 Logit Working Papers and related analyses provides a continuing resource for exploring the scientific, methodological and educational issues introduced in the program.

The papers address representational and ratio measurement, measurement and curriculum inversion, admissible arithmetic, dimensional homogeneity, utilities and QALYs, Rasch measurement, patient-reported outcomes, reference-case modelling, formulary evaluation, HTA agencies, university programs and the reconstruction of graduate HTA education. State, national and institutional interrogations provide further examples of how the measurement problem appears across different academic and decision-making environments. The website therefore functions as an expanding measurement knowledge base, rather than simply an archive of individual papers.

This broader resource matters because curriculum transition cannot be reduced to mastering a fixed body of instructional material. As faculty begin applying measurement principles to courses, research programs and therapy-evaluation problems, new questions will arise. Participants can pursue these through the working-paper collection while drawing upon continuing interaction with Maimon Research for their particular applications.

The combination is deliberate: the nine units provide the educational foundation; the website provides the supporting knowledge base; and continuing interaction supports application and curriculum development.

INTRODUCING MEASUREMENT INTO THE HTA CURRICULUM

The longer-term objective is not to maintain two incompatible quantitative frameworks indefinitely. Introducing lawful measurement alongside established teaching is a transitional strategy. Once faculty and students acquire the necessary measurement knowledge, the ordering of the curriculum itself can be reconsidered.

An introductory graduate course in HTA should begin not with economic evaluation, utilities, QALYs, ICERs or decision modelling, but with measurement. Students should first understand the concept of an attribute, what it means to measure that attribute, and how nominal, ordinal, interval and ratio scales differ in the quantitative operations they permit. The curriculum should then progress to admissible transformations, dimensional homogeneity and, critically, ratio measurement as the requirement for multiplication, division and meaningful ratios. This provides the foundation for distinguishing manifest from latent attributes and understanding the different measurement pathways required for each.

Only after this foundation has been established should students encounter the quantitative methods of contemporary HTA. Economic evaluation and modelling can then be examined against prior measurement requirements, enabling students to determine whether the quantities employed possess the properties required for the arithmetic performed.

Universities are not required to construct this framework independently from first principles. The framework already exists**.** The nine-unit program provides a structured basis from which measurement principles can initially be introduced alongside existing teaching and subsequently incorporated into a dedicated graduate curriculum.

The essential curriculum transition is one of scientific ordering: attribute first, measurement second, admissible arithmetic third, and quantitative analysis thereafter.

A CHOICE FOR UNIVERSITIES AND RESEARCH CENTERS

The challenge facing university HTA education is therefore one of transition rather than simple curriculum expansion. The accumulated measurement and program-content findings identify a scientific problem that cannot be resolved by adding greater sophistication downstream. More elaborate modelling, additional sensitivity analysis and increasingly sophisticated statistical procedures cannot substitute for establishing measurement upstream.

Nor should faculty be blamed for having been educated within the inherited framework. The absence of representational measurement from their own training helps explain why that framework has been transmitted to subsequent generations. Once the omission has been identified, however, the educational situation changes. Another generation of students should not encounter quantitative HTA without being given the measurement principles necessary to evaluate its claims.

Universities do not have to accept the measurement critique in advance, abolish existing courses or ask individual faculty members to construct an entirely new curriculum unaided. They can begin by providing faculty and students with a structured foundation in lawful measurement and allowing its implications for existing teaching and research to be examined.

The nine-unit program is offered as that starting point: a foundation for faculty preparation, student education and the development of a measurement-based graduate HTA curriculum. The first step need not be immediate abandonment of an established curriculum. It is to give faculty and students the measurement knowledge required to determine for themselves whether that curriculum can survive scientific scrutiny.

The measurement problem has been exposed. The next question is educational: who will teach the next generation how to solve it in Texas?

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