Conceptual Meta-Models: An Example Correlating Anthony's Triangle, Simon's Structure, and Stevens' Scale of Measurement

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Models vary in size and applicability. However, the goal of most models is to abstract a complex topic and make it simple enough for multiple people to understand and discuss the topic. As a result, there should be utility in being able to craft the most complex and descriptive model for any given situation using the most simple pieces. This paper proposes this idea, and gives an example with the correlations between Anthony's Triangle, Simons' Structured and 'ill-structured' problems, and Stevens' Levels of Measurement. The end result is an acknowledgement that there is a lacking setoff universally agreed upon core models that can be used for brainstorming and a call to develop a universal grammar of standard models for widespread recognition.

Keywords: conceptual model, information systems, decision sciences

INTRODUCTION

Conceptual model development is one of the most underlying methods of communication within most business fields. The general notion is to simplify complex ideas so that they can be discussed and considered while any decisions maintain applicability to the real world. The result of this is a plethora of models having been developed, with only a few of them still being actively taught and used. Models such as the SWOT approach have legitimacy but no provenance, whereas models like the MBTI have provenance but no legitimacy. This then devolves into a smattering of tools that many will recognize but not always have much experience using.

Typically, two methods are used for conceptual model development in the business world. They scale variably like Porter's Generic Strategies. The most successful are the ones that either seek to model every aspect of the real world while still segmenting it into easier to calculate pieces or the models that seek to simplify the conceptualizations into the smallest number of entities in a very Shibui style.

However, just like Porter's Generic Strategies were modified by a novel application that suggested a third value-based strategy that did not lie on the continuum between differentiation and cost-leadership, it is feasible to suggest that there is a third method of conceptual model development. This third method could be seen as a hybrid approach, but we posit that it is a novel form, seeking to provide as much real-world specificity as possible while still maintaining the abstraction benefits found in a simple model.

So, within this paper, we would like to suggest that the utility of using a conceptual model to simplify complex tasks without losing applicability to real-world decision-making can be magnified by combining several models to provide depth or interpretation, reinforcing a larger gestalt of each model while still utilizing a common set of simple, well-proven conceptual models.

LITERATURE REVIEW

There are many general business conceptual models that can be applied here. One thing that will be necessary for this particular approach to work will be to utilize simplistic models. For example, suppose a model to be functional requires a pre-printed worksheet, or drawing dozens of diagrams. In that case, it will be more difficult to conceptualize how the different parts fit in with other models. Rather, 'back of the napkin' type models that only require a handful of lines to be interpretable are more ideal. Similarly, to appeal to the widest range of people, common ones should be selected. As a result, the following three have been chosen, each reinforcing the other as a baseline model from which others can spring.

Anthony's Triangle has a long history of utility. It is a foundational model within the information systems sphere, dealing with process design and automation. Anthony's Triangle was originally described as a pre-computer revolution method of design for factory organization (Anthony, 1965). However, as is often the case, the model was simplified and given its more iconic pyramidal shape and nominal appellation by Gorry, et al. (1971), a few years later. It could be argued (and is the position of this paper) that it is widespread enough and genericized to the point that it is part of most managers' common knowledge pool. Full disclosure, the authors have already written about the shortcomings of this approach, but changing the structure of the model muddies the water compared to the overwhelmingly more popular pyramidal structure (Larson & Friesen, 2019).

Similarly, Herbert A. Simon coins the term 'bounded rationality,' eventually building up a model of structured v. ill-structured problems that could ideally be solved within the same problem-solving frameworks (Simon, 1947). Over time, and lost to adequate referencing, this idea has been generalized to a concept of structured versus unstructured decision-making. This spectrum is then bisected by a middle concept of semi-structured problems, which is the modern replacement for a concept Minker promulgated in the 1970s (Gallaire & Minker, 1978). The result is either a progression from structured to semi-structured to unstructured problems or a progression from structured to unstructured decisions, with semi-structured adding constraints to the unstructured decisions making them computationally simpler. It is the authors' position that these three terms, structured decisions, unstructured decisions, and semi-structured decisions, are well within the purview of general knowledge for the field.

Finally, there is Stevens' standard work on levels of data (Stevens, 1946) which distinguished data into four discrete levels: nominal, ordinal, integral, and ratio data. It is also easily derived into what can be done with the data: nominal can is given a label only (), ordinal is given a name and a relative order (Greater Than, Less Than, Equal To, Not Equal To), integral is given a name and a relative order and the ability to combine values (Greater Than, Less Than, Equal To, Not Equal To, Add, Subtract), and ratio data gives meaning to 0 and allows for multiplication and division (all operations). Once again, it is the position of this paper that these concepts are all well within the scope of general knowledge.

Of particular note with Stevens' scales of measurement, the ultimate model will likely arrange the data such that it has qualitative and quantitative data at either end, with partial, mixed, or either data holding a middle position. The justification for this is that ratio data can be used in any further mathematical derivation, integral and ordinal data are limited, and nominal data can only be used in one capacity. The result is that ratio data would always be capitalized as quantitative data, nominal data would always be capitalized as qualitative data and integral/ordinal data is partial data since they can't always be used quantitatively, but they aren't always as mathematically limited as pure qualitative data. Similarly, there are situations where a mix of quantitative and qualitative data might be used or situations where either would be feasible because it is not of primary importance.

These three models make up the primary models that will be associated together to develop a newer, higher-resolution model from just a few small parts.

In addition, while several people have correlated the relationship between Anthony's Triangle and the relative structured or unstructured quality of a given problem (for example, Chi, et al, 1982), the most direct tends to be in textbooks referencing general knowledge (such as Kroenke & Boyle, 2014). However, there does not seem to be a lot of refereed support for the idea. However, it does seem to be intimated in Gorry during their justification for their proposed framework.

FRAMEWORK

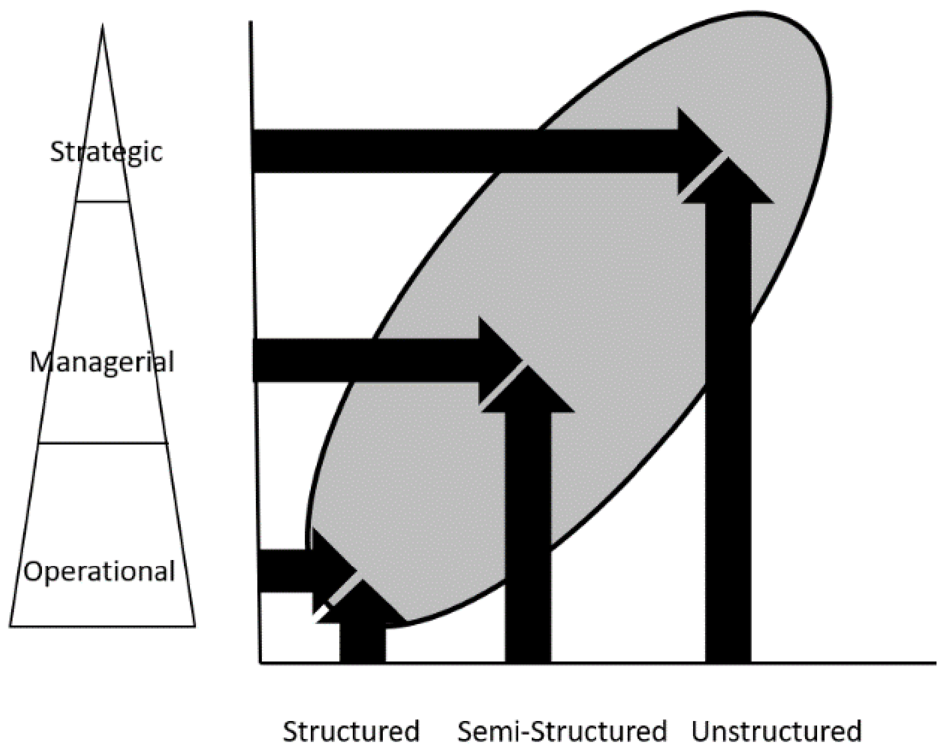
These models are separate models with separate intents. But they tend to act within the same sphere: decision-making. Kroenke and other reporters of 'generalized knowledge' tend to imply Anthony's triangle and Simon's structuredness are both continuous scales and then further contend that there is a non-perfect but general correlation between the two. Since there are three elements of both models, it makes sense to make this connection. In particular, we can lay them out below:

- Structured Operational Decisions – The first layer suggests that while it is feasible for an operational level role to be engaged in higher-level tasks, the reality is that the operational level follows the process that is defined for them, and the answers to any given problem are proscribed directly. An example would be call center technicians who are expected to follow a script exactly at the first tier.
- Semi-Structured Managerial Decisions – This level suggests that managerial decision-makers face what would otherwise be unstructured decisions, such as 'who is the best employee to schedule at a given time' or 'how can I motivate my team members or similar problems that are qualitatively difficult to optimize. However, because of their role within the organization, the questions are always constrained by the dictates of higher-level decision-makers, so the question is, 'What is the answer to a given unstructured problem within the constraints of organizational policy.'
    - One side effect of parlance differences between differing colloquial usages of terms seems to be (reducing variation for clarity): structured decisions become more complicated and become semi-structured decisions, implying that the increase in complexity is what removes some of the constraints of the lower level. This paper will use this notion as it is easier to fit into the limited scope of this article. However, the other approach that semi-structured problems are an afterthought, and a result of trying to utilize structured problem solvers (such as cheaper employees and technological solutions) seems to have a more applicable framework to technological applications.
- Unstructured Strategic Decisions – This level suggests that despite needing to frequently follow some constraints (legal, physical, financial), for the most part, the strategic level decision maker is only constrained by the creativity of their problem-solving. So, strategic decisions are made by unstructured problem solvers at the company's leadership role.

Again, this distinction is not intended to suggest any specific or direct correlation. It is suggested that this relationship is implied by the nature of the similar complex objects being modeled (problems and decisions) and the nature of the similar structure that has been generally assigned to this process.

Comprehensively, it's important to note when crafting a framework like this that a certain amount of shared history and storytelling is necessary for both the author and the reader to buy into an idea. For example, one conceit of a military mindset would suggest that the previous presumptions are incorrect and that every problem solver needs to consider every level of decision-making (Zweibelson, 2012). However, since models are, again, very context-specific, it is feasible for there to be disagreement. In addition, should this non-correlative conceptualization of the idea be used, it just presents nine situations to plan for rather than the current 3. The result is that while it's possible to make all of these models more complex, as a general outline, abstraction is also feasible when needed. For example, extemporaneous problem-solving often requires simplicity rather than complexity.

FIGURE 1
RELATIONSHIP BETWEEN ANTHONY'S TRIANGLE AND SIMON'S STRUCTURE



Thus, finally, to the novel addition presented with this framework: the level of measurement will also apply to this framework. Earlier, the descriptive element showed that, of course, the level of measurement can be reduced to qualitative, quantitative, or mixed. We will use 'mixed' to refer to partial, mixed, or 'either' categories (synecdoche rather than TLA). We posit that there is an inverse correlation between Stevens' levels of measurement and both Anthony's Triangle and Simon's Structuredness and the already described correlatory model.

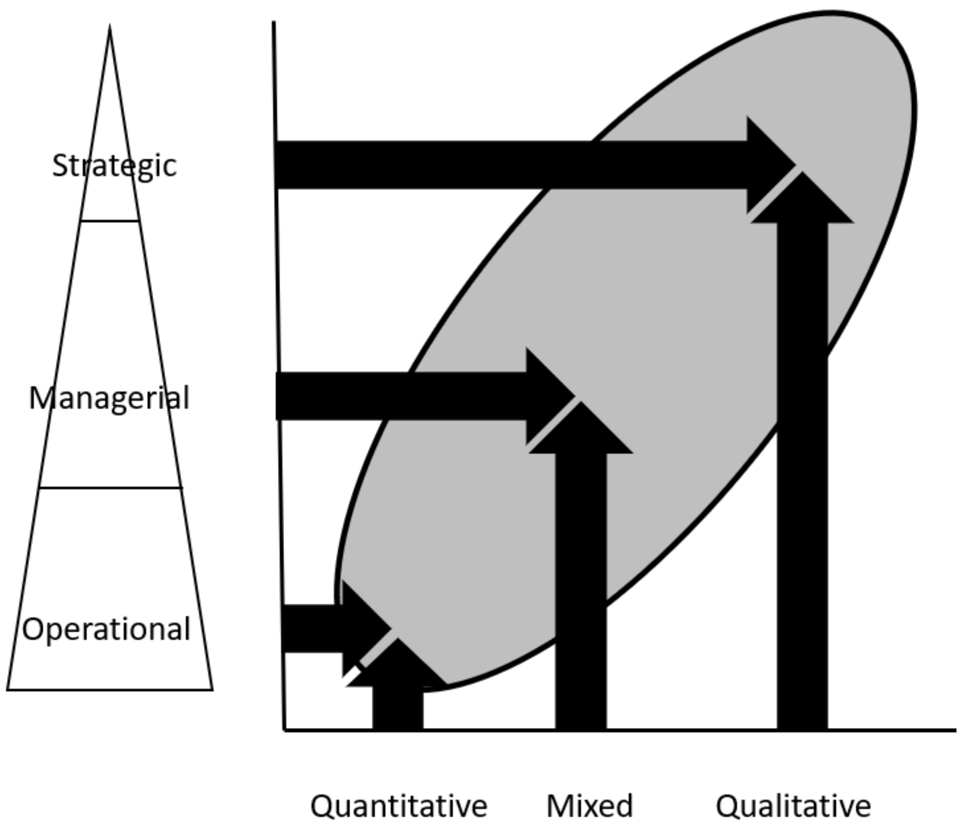
A brief description of the Levels of Measurement v. Anthony's Triangle:

- Operational Roles tend to prove their solutions with quantitative data – This is not a historically necessary trend. However, using large data sets, employee direction can be mitigated down to minimal numbers. For example, a chef who is cooking fries might be able to determine whether the fries are done to their goals based on various temporary metrics. However, a fry cook at a fast food restaurant is dictated by exactly how many seconds the fries need to be in a fryer at an exact temperature with instructions for exactly how long they can stay on the warmer afterward. Even the final result is oriented around quantitative taste tests targeting the highest level of satisfaction amongst large-scale testing. The more operational the role, the more the correctness of their decision is justified quantitatively.
- Managerial Roles tend to prove their solutions with mixed data – In this scenario, a manager making decisions faces pressure from two sides. Operational Level employees are rated in performance, typically quantitatively, but there is often a qualitative backup. Neither the qualitative value can be solely used nor can the quantitative value. Example would be an

employee scheduled for a raise: high quantitative ratings need to be supported with positive qualitative comments from peers and supervisors. Similarly, when an organization wants to fire an employee for qualitative reasons, they often build up a history of poor quantitative ratings to support the qualitative overview.

- Strategic Roles tend to prove their solutions with qualitative data – One caveat: this is not suggesting that strategic managers do or should use their ‘gut’ or ‘instincts’ to make decisions. The qualitative data referenced here is intended to be one of empirical value and general acceptability from a good-faith perspective. Because strategic roles tend to be thinking about unpredictable futures, goals, visions, and broadly categorized if-then statements, it’s difficult to rationalize why any given conclusion is the optimum answer with numbers: a different set of presuppositions will drastically change that conclusion.

FIGURE 2
RELATIONSHIP BETWEEN ANTHONY’S TRIANGLE AND LEVEL OF DATA



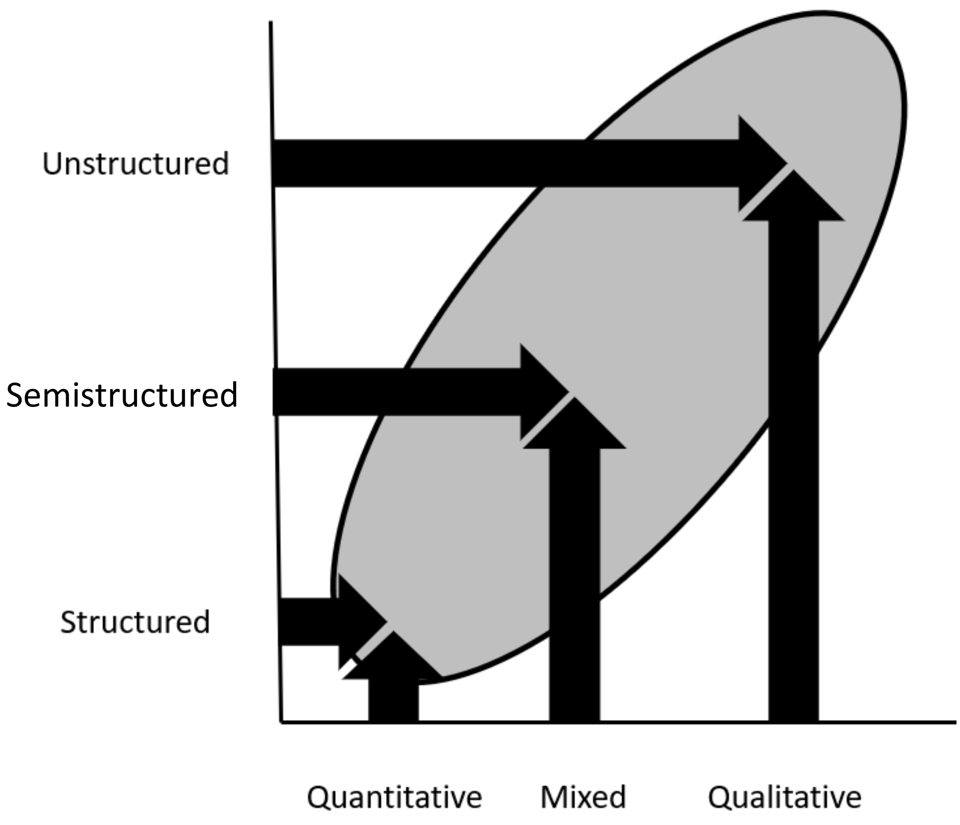
In short, the previous three points suggest that decision-making always involves an element of predicting the future. To the extent that it’s possible to justify any decision, it’s empirically easier to justify shorter-term decisions with quantitative data than longer-term decisions.

Similarly, a brief description of the Levels of Management v. Simon’s Structuredness:

- Structured Decisions tend to revolve around quantitative data – When making a decision that follows a structured decision model, the data tends to revolve around quantitative data regularly. Solutions tend to orient themselves around repeated processes, and Metrics lead to processing at higher levels that filter down to operational decision-making in very fixed heuristics. There is one slight variation here (well within the idea of imperfect correlation), and that is that Boolean data would need to be classified as quantitative data since simple decisions will be coded as a strict true or false categorization. Even still, when dealing with large sample sizes of Boolean, textual, or other unstructured data, the coding in a structured decision will revolve around repeated decisions that need to be made the same way every time, meaning that the outcomes are planned based on repetition and frequency in a derivative form.

- Semistructured decisions tend to revolve around mixed data – Decisions in the semistructured environment may need to be characterized by extra decision-making that skews strictly structured environments. Rather than a fixed set of decision makings, the solution domain to any given decision can be restricted through quantitative data. Still, the solution to any individual problem may require interpretation of the data through metadata, additional qualitative data, or other observations of the decision maker.
- Unstructured decisions tend to revolve around qualitative data – Higher level decisions tend to be decisions that are oriented around the interpretation of goals, organization of non-ordinal network graphs, or expert system type data where the experience of the decision maker or the advisors plays a larger part in more complex decisions than simple statistical analysis will account for.

FIGURE 3
RELATIONSHIP BETWEEN SIMON'S STRUCTURE AND LEVEL OF DATA



Of the three correlations described so far, this third is the weakest. Any given pairing between the data's structuredness and the measurement level can be countered with specific examples. However, as with all conceptual models, the goal is to simplify a complex environment through abstraction. So while it's reasonable to assume that an unstructured decision will use some amount of quantitative data, the unstructured nature of the decision implies that there will be a large amount of error in a purely statistical evaluation as well as an abundance of agency on the part of the decision maker in deciding the relative reliability of any given framed decision.

However, the real goal of these relations is to suggest that, transitively, if we can declare that any given structured decision can be correlated to Anthony's Triangle, that Anthony's Triangle can be correlated to a level of measurement, and that levels of measurement can be related to the structure of the decision, then it should be possible to make a conceptual model that incorporates all three of these.

CONCEPTUAL METAMODEL

To frame this newer model, we need to first reframe the process of making a decision. We can use basic terminology to outline a naïve approach to decision-making. That is: there exists a problem domain that contains all forms of any problem, a solution domain that contains all conceivable solutions to any problem in the problem domain, and a relation between the problem domain and the solution domain which represents the provability of the relative goodness of any given problem to the solution.

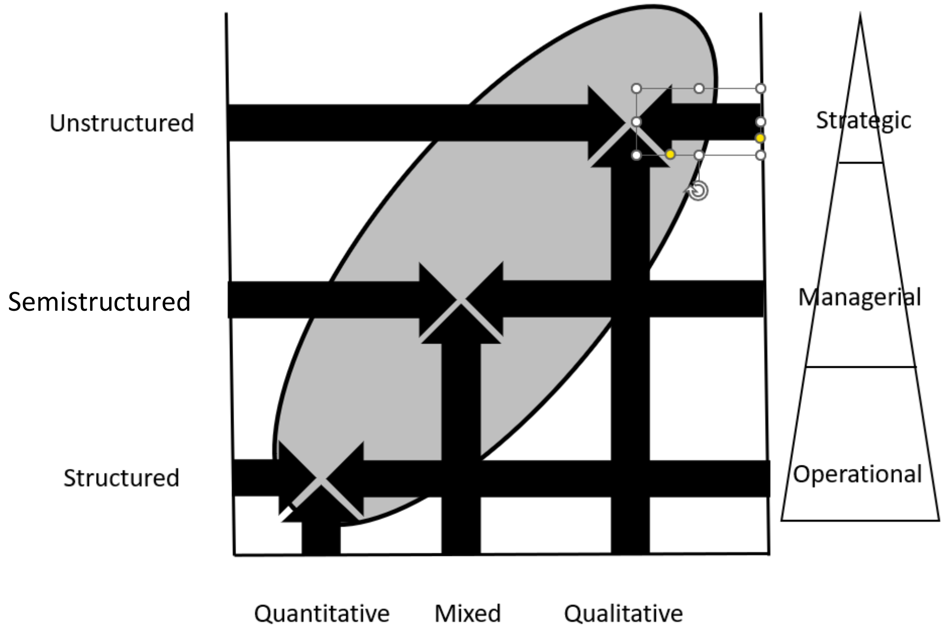
Within this framework, we can refactor the prior relationships:

- Operational Level Problems have Structured Solutions that have a provable heuristic – Alternately, we could say that any given operational level problem domain is fixed and highly constrained, while the solution domain is also fixed and relatively small, and the suitability for any individual solution to any individual problem is also fixed and demonstrable.
- Managerial Level Problems have Semistructured Solutions that have a heuristic with undetermined provability – Alternately, we could say that any given managerial-level problem has a larger problem domain, but a small and unfixed solution domain, where the relationship between any individual solution to any individual problem is not provable; however many of those relationships may be provable within a certain threshold (that is: a good solution but not guaranteed to be the best solution; satisficement).
- Strategic Level Problems have Unstructured Solutions that have an unfixed relationship – Alternately, we could say that the problem domain is of indeterminate size that is up to infinitely large, the solution domain is also of indeterinate size that is up to infinitely large, and there is no method for quantitatively proving the suitability of any solution for any problem.

Laying out an ideal framework: The first level of this model would have specifically described problems with a single solution that is immediately verifiable. The second level would have well-defined, inspecific problems with multiple solutions with general guidelines on demonstrating their effectiveness. And the third tier is a set of unknowns.

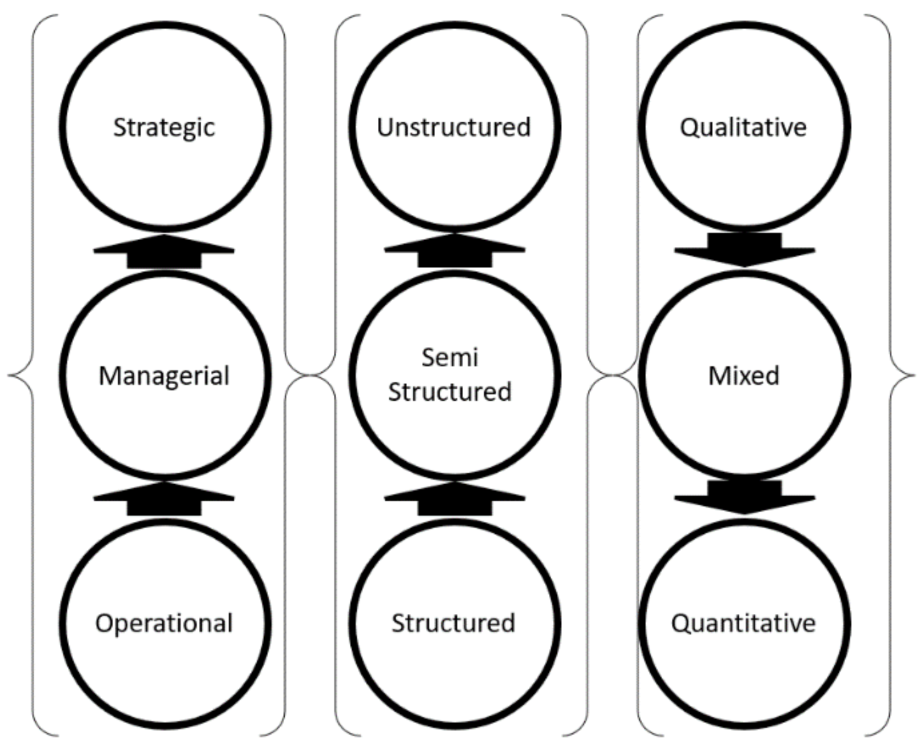
One slight variation of note: it seems like it should be possible to frame this framework as a solution domain, a problem domain, and a process domain. However, that would likely be more effective in a practical and applied paper later.

FIGURE 4
RELATIONSHIP BETWEEN ANTHONY'S TRIANGLE, SIMON'S STRUCTURE, AND LEVEL OF DATA



CONCLUSION

FIGURE 5
TOPOLOGICALLY EQUIVALENT MODELS



The goal for this project is to be able to create a complex framework for highly adaptable problem-solving methods using the simplest number of ‘back-of-the-napkin’ type models that are ubiquitous, easy to understand individually, easy to explain, and lead to framing and understanding problems better. With that regard, the authors feel that this is an excellent proof of concept.

In this example, we can demonstrate that the three selected models are topologically equivalent. When drawn, they are three entities easily diagrammed with, say, three circles connected in a stack formation. Using these three models, we can quickly layout, in broad strokes, that there are 27 possible modeled zones within a three-axis graph. And, since the model proposes a correlation between the three models, this meta-model would be able to quickly cull the possible ways to frame any given system of decisions, solutions, and processes down to 3. The benefit being an immediate and explainable method of directing any planning or brainstorming sessions into a specific direction, particularly able to take complex problems and narrow them down to a more clear lane of collaboration.

One glaring deficiency in a wider adoption of this methodology for crafting meta-models on the fly is the lack of an agreed-upon set of component models. While there are obvious historical examples of trying to define one superset of models (Munroe), there may still be some benefit in crafting a grammar of models. Having a set of simple but historically significant topologically similar models as well as specific named and ubiquitous models that are available as a base reference would increase the utility of any similar endeavor.

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