Notes on complexity in Learning Analytics, Category Theory, Topology

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Notes on research around understanding the theory - practitioner gap, particularly in regards to Learning Analytics.

Defining the problem

Let us start at this beginning; there is a thing out there we call the world, and there are people in it.

The latter often find the aspects of the former somewhat mysterious and as a result, try to make sense of it. Now we have three things; aspects of the **World** that a particular **Person** tries to make sense of by some **process** Λ which we can draw together with some boxes and an arrow:

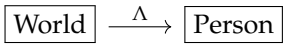

Figure 1: A diagram to help make sense of a person making sense of an aspect of the world through some sense making process, Λ.

There are many of ways to make sense of the world, but let us explore a rough dichotomy between *experiential* and *analytical*.

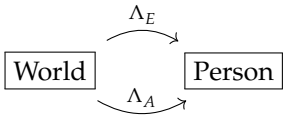

Figure 2: Different ways to make sense of the world, experiential (Λ_E) and analytical (Λ_A).

The *experiential* way of making sense of the world represents what the mind does to connect ones lived experience to a conceptual model of the world. The *analytical* way can be thought of as a process that can be separate from the lived experiences of the person, that instead attempts to build an understanding of the world through *data* and analytical methods[1].

At this stage it is worth diving into what World and Person are. World represents an (or any, or all) *aspect* of the world we live in that we are trying to understand. In a way this only makes sense if we introduce a particular person, which is another *aspect* (this time of the Person structure[2]) who is trying to make sense of some aspect of the world. This "making sense of" process is an example of a *mapping* or *map*[3] from one space to another.

[1] Not to say that the *analytical* way is somehow more true than the *experiential* way - the end result is an interpretation of the world

[2] Later this will be defined precisely as a Category, which has a precise mathematical meaning, but for now the word *structure* lends itself better to developing the correct intuition.

[3] More formally these are examples of *functors* between *categories*.

For example, a parent might be trying to understand why the later it gets the more energy their four year old child seems to have, seemingly contradicting the first law of thermodynamics. Here the aspect of World could be described as *energy levels of small children approaching bedtime*, the aspect of Person is a parent. This is puzzling because they have an analytical way to make sense of this phenomena (a mapping from World to Person using the law of conservation of energy in a closed system) and this does not seem to align with their experiential understanding of the aspect (said child is now doing laps of the dining table whilst singing, despite having not eaten dinner).

The composition of analytical sense making

We can pull apart the analytical sense making map, Λ_A, into a series of steps.

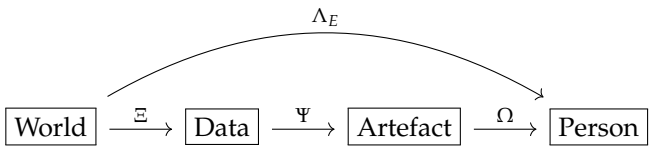

Figure 3: Decomposing the analytic sense-making, Λ_A, into three steps; the *epistemic cut* Ξ, the *analysis* Ψ, and the *interpretation* Ω.

Ξ : Epistemic Cut

The first step in analytical sense-making we shall call the *epistemic cut* [1] and takes us from some aspect of the world we are interested in to a data set. This is a subjective map from the 'real' world to the world of symbols and information. It should be apparent that this is critical to the final understanding of the phenomena of study, for instance if one decides not to include *race* or *gender* ...

Suppose some teacher is interested in how well a group of students have understood the content of their course. Some possible options for Ξ include:

- Setting an examination on the topic. The choice of questions here is an epistemic cut in itself; open or closed questions, multiple choice, essay with an unseen or seen question.
- Conducting interviews / discussions with the students, possibly in groups or as a whole.
- Having students reflect on their learning in a journal. This could be marked according to some rubric or may just be read by the teacher, with no mark assigned.

- Observing the students as they learn and discuss the topic.

Note that the epistemic cut may involve actions to produce the data; for instance notes would probably be taken from the observation of the students as they learn in order to produce data to analyse.

Ψ : Analysis

The second step in analytical sense-making we shall call *analysis* and takes us from the data set to some kind of artefact. This artefact could be a graph, a report, a number - anything that is used to convey the results of the analysis.

Imagine we have a set of examination results as out data, which we can view as an $n \times 2$ matrix of $(student, score)$ pairs. Some possible options for Ψ include:

- Listing the students whose *score* is below a certain threshold (say 0.5).
- Taking the mean of the *score* values.
- Plotting the distribution of the *score* values, and marking the mean and median on the plot.

Ω: Interpretation

The third and final step in analytical sense-making we shall call *interpretation* and this takes us from the artefact to a person's understanding of what the artefact is saying about this aspect of the world. This map is part cognitive and biological and dependent on many external factors; the role of the observer, the type of artefact, the ...

Expanding on the examples previously, the interpretation of a set of "how well did my students understand the topic" is quite different

In Figure 3 it is assumed that the two paths from $\boxed{\text{World}}$ to $\boxed{\text{Person}}$ are equivalent, which means the diagram *commutes*. This may not always be the case, particularly when order is important.

THat said

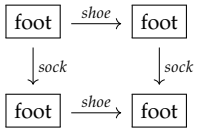

Figure 4: Different paths sometimes lead to different places

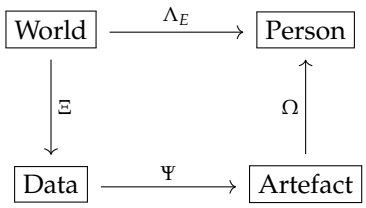

Figure 5: Two different paths for a person understanding an of the world; an analysis process broken into three steps ($\Lambda_A = \Omega \circ \Psi \circ \Xi$) or through interpreting experiences (Λ_E).

Scrapbook

Examples to play with at a later date

Example of conflict between experiential and analytical - inserting a USB drive.

Astrological predictions / star signs.

References

[1] H.H. Pattee. The physics of symbols: Bridging the epistemic cut. *Biosystems*, pages 5–21, 2001.