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Foundations for the Future

Gardner-Inspired Dog-legged Design of Teaching Materials – A Logical Illustration

Laurence Goldstein and Martin Gough

Wednesday, July 13

HEA – University of Greenwich

Are the techniques and teaching materials I now use effective and exciting?

Are there elements of what I teach that students consistently don't seem to grasp?

Do I succeed in transmitting to my subjects the deep understanding and true love for it that I feel?

Are my materials well suited to students with cognitive or physical disadvantages?

Am I going to stick with the standard tools that are commercially available or can I do better myself?



OK – but where
do I start?

Are there principles governing materials design?

How do I test whether what I design is pedagogically effective?

How do I build prototypes and go into mass production?

The dog leg

A design methodology based on Howard Gardner's Theory of Multiple Intelligences

Howard Gardner's Intelligences

Linguistic intelligence

Logical-mathematical intelligence

Spatial intelligence

Bodily-Kinesthetic intelligence

Musical intelligence

Interpersonal intelligence

Intrapersonal intelligence

Naturalist intelligence

The beginnings of logic

Aristotle's sweet *Analytics* ravished generations of European scholars and scientists. The *Prior Analytics* displayed the pure discipline of logic, well-formed, elegant, seductive; the *Posterior Analytics* beckoned to deeper mysteries, offering a sure path to scientific progress, clear and imperious in its injunctions, delicious in its rigour.

Example of Barbara

All Jon's children are geniuses (JaG)

All geniuses have exceptional parents (GaP)

Therefore

All Jon's children have exceptional parents (JaP)

Example of Celarent

No sulphide ions are dithyramps (SeD)

All pleistoscopes are dithyramps (PaD)

Therefore

No sulphide ions are pleistoscopes (SeP)

A syllogism not obviously valid

Some tax cheats are parliamentarians (TiP)

No blue-eyed people are tax cheats (BeT)

Therefore

Some parliamentarians are not blue-eyed (PoB)

“Perfect” syllogisms

Form	Mnemonic	Proof
Aab, Abc ⊢ Aac	<i>Barbara</i>	Perfect
Eab, Abc ⊢ Eac	<i>Celarent</i>	Perfect
Aab, lbc ⊢ lac	<i>Darii</i>	Perfect; also by impossibility, from <i>Camestres</i>
Eab, lbc ⊢ Oac	<i>Ferio</i>	Perfect; also by impossibility, from <i>Cesare</i>

Proof of *Camestres*

(thanks SEP)

Step	Justification	Aristotle's Text
1. MaN		<i>If M belongs to every N</i>
2. MeX		<i>but to no X,</i>
To prove: NeX		<i>then neither will N belong to any X.</i>
3. MeX	(2, premise)	<i>For if M belongs to no X,</i>
4. XeM	(3, conversion of e)	<i>then neither does X belong to any M;</i>
5. MaN	(1, premise)	<i>but M belonged to every N;</i>
6. XeN	(4, 5, <i>Celarent</i>)	<i>therefore, X will belong to no N (for the first figure has come about).</i>
7. NeX	(6, conversion of e)	<i>And since the privative converts, neither will N belong to any X.</i>

Boolean algebra

(In a more elegant notation than Boole's)

$SD = 0$ (No S are D)

$P\check{D} = 0$ (All P are D)

$SPD = 0$

$SP\check{D} = 0$

Therefore $SP = 0$ (No S are P)

Proof by diagrams

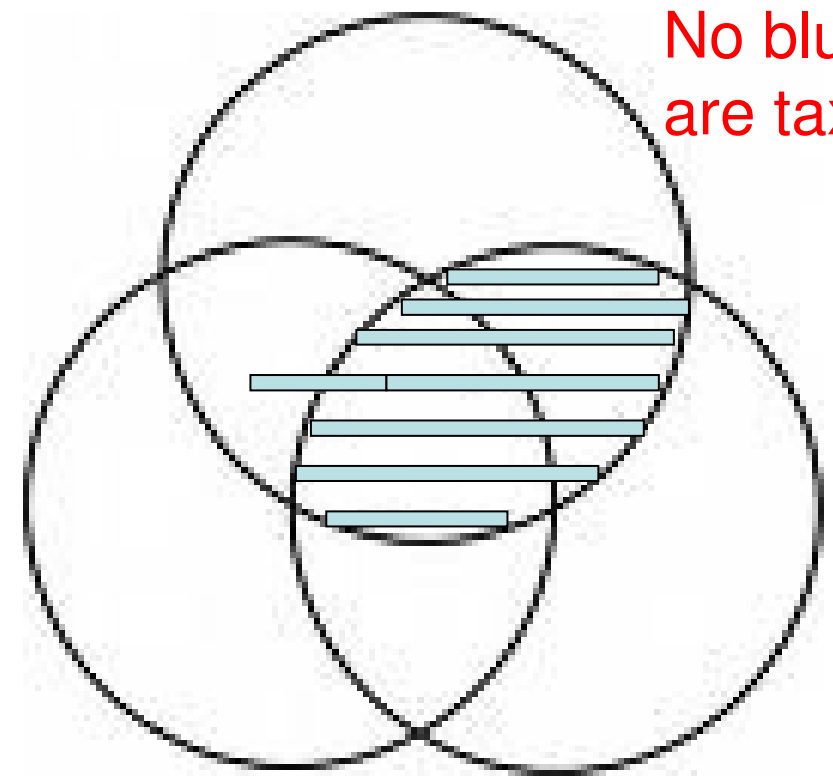
“there is no principled distinction between inference formalisms that use text and those that use diagrams. One can have rigorous, logically sound (and complete) formal systems based on diagrams.”

(Barwise & Etchemendy)

Some tax cheats are
parliamentarians

Tax cheats

No blue-eyed people
are tax cheats



Blue-eyed
people

Parliamentarians

Some parliamentarians are not blue-eyed

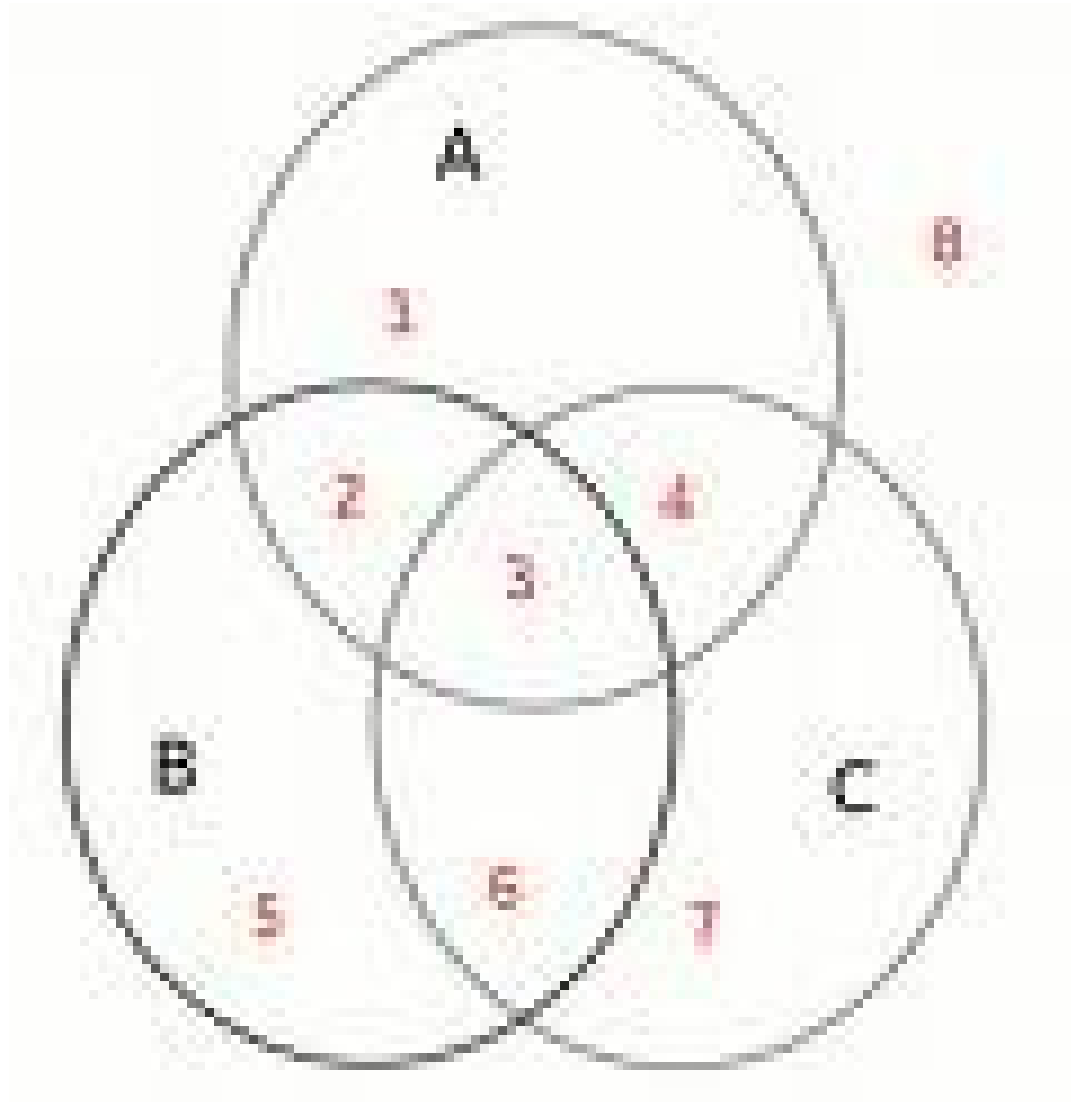
Is this important?

..... or is it like the theory of phlogiston?

1. Notion of argument as a subject of scientific enquiry and the possibility of codifying rules for arguing well.
2. Solving a problem by projecting into different modalities (Euler)
3. Fundamental notion of a set, set/aggregate distinction, operations on sets.
4. Syllogistic superseded, but remains true and beautiful.

How to teach this to the blind

1. We cannot rely on visual spatial intelligence, but must engage some other modality.
2. Must avoid superficial learning, e.g. merely memorizing the 19 valid forms, or entering the premises and conclusion into a computer program and hitting 'test'.
3. For each Gardnerian intelligence there is a spectrum from low to high – from shallow learning to deep understanding. We are aiming for deep learning.



Venn and Sylloid operations compared

1. Shading of areas to show they are empty. Removing tetrahedra, creating an empty space.
2. Indicating possible presence of objects with a bar ...with a textured hinge piece.
3. Remove that possibility by shading out the bar. Removal of a tetrahedron leaves one side of the hinge unattached, and it is folded right back on itself, exposing the textured surface.

Phase 2: A design for the sighted

Can we incorporate the virtues of Sylloid into the design of a new tool, Son of Sylloid, for *sighted* learners? If so, then we should end up with a tool superior to Sylloid and superior also to Venn Diagrams.

Son of Sylloid for the sighted

1. Preserve the learning advantages of the 3-dimensional model over the graphical, algebraic and Aristotelian methods.
2. Redesign the apparatus in such a way that the sense of sight can be re-engaged.
3. Further enhance deep understanding once the capacity for tapping into visual spatial intelligence is restored.

Generalizing the Dog-legged Methodology

1. Consider any bit of knowledge or skill currently not well taught using traditional techniques.
2. Design a tool T for learners (real or imaginary) who are deficient in a certain respect or who are weak in some Gardnerian intelligence(s).
3. Construct a Son of T, incorporating the pedagogical advantages of T, but designed for non-impaired learners.
4. Laugh all the way to the bank.

What's happening now?

- An exploitation project – funded by University of Kent Innovation & Enterprise
 - focus groups and workshops for school sector professionals
- Intellectual matters – what does this tell us about the nature of ‘deep learning’?

Gracias

y

Buenas Noches

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