Structural Features connect the form and function of representations for learning and doing physics.

Structural Features of External Representation in Physics

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A *representation* is **organized information** about a **conceptual referent** presented in a **medium**.

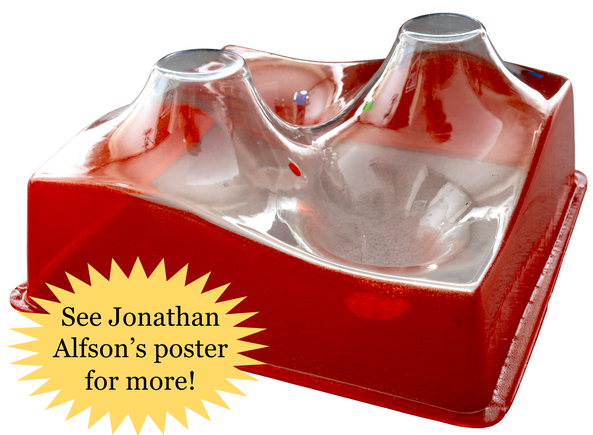
We identify **9 structural features** that are illustrated below with two examples.

Features of professional representations can be opaque or overwhelming for learners. Features that are helpful to learners can feel clunky to experts.

Fidelity to Referent

Proportional relationship between height and potential on the Surface is intuitive.

Surface Model of the Electric Potential of a Quadrupole



Configurability

Shape of the Surface cannot be changed but can be annotated with dry-erase markers.

Externalization

On the Surface, the value of the potential is represented for most points in the domain. (In contrast to a contour map, which externalizes select values of potential)

Support for Procedures

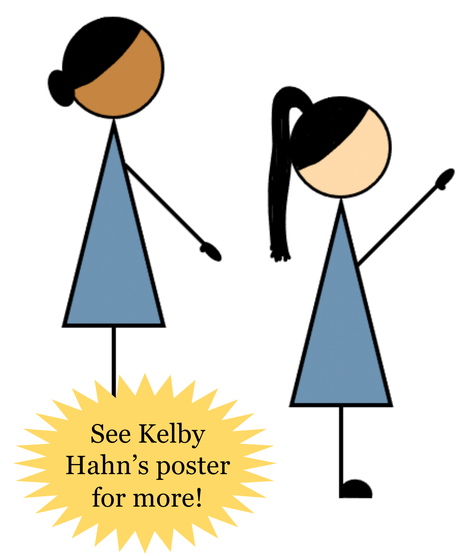
Surface dry-erasability and transparency help students connect level curves with contour map.

Individuation

On the Surface, height represents the value of potential and is vertically separated from location of the field point (unlike a contour map).

In ARMS, basis states (individuals) and coefficients (arms) are distinct.

ARMS Representation of a Quantum Spin State



Ease of Use

ARMS does not have specialized equipment but does need multiple people for quantum states.

Tolerance to Noise or "Digital-ness"

Angles with ARMS are only approximate but recognizing constant vs. changing relative phase is remarkably digital.

Precision

Both representations are good for qualitative judgements but making precise measurements is not easy.

Compactness

ARMS requires space to swing arms and line up people.

Definitions of the features can be found in the preprint at:
https://osuper.science.oregonstate.edu/papers/structural-features

Scaffold learning by sequencing features:

Start with More Intuitive

- Fidelity to Referent — High → Low
- Ease of Use — High → Low
- Support for Procedures — More → Less
- Individuation — More → Less

Start with Less Information Density

- Externalization — More → Less
- Compactness — Less → More
- Tolerance to Noise — More → Less
- Precision — Less → More
- Configurability — Less → More

The Surface and ARMS representations have pedagogical advantages and are good early representations for learners:

- easy to use
- limited configurability allows interactivity while students focus on a few key features
- high individuation of key elements
- good support for exploring conceptual relations
- externalize key features to reduce cognitive load
- intuitive fidelity to referent (for the Surface)

Find out more:

Pedagogy
https://paradigms.oregonstate.edu
Research
https://osuper.science.oregonstate.edu

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