?Discovery-based? Learning Pushes Students Over the Threshold

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The divergence theorem $\int_V \boldsymbol{\nabla} \cdot \boldsymbol{v}\, \mathrm{dV} = \oint_S \boldsymbol{v} \cdot \hat{\boldsymbol{n}}\, \mathrm{dS}$

It relates to how much things 'spread out'

- Air or other gasses
- Liquids
- Heat or other energy
- Mass
- Momentum
- Force fields
- Electric fields

Engineers need to understand and use it

The divergence theorem $\int_V \nabla \cdot v \, \mathrm{d}V = \oint_S \boldsymbol{v} \cdot \hat{\boldsymbol{n}} \, \mathrm{d}S$

It’s not a *basic* concept

“It’s scary”

It’s a *threshold* concept

- Transformative
- Irreversible
- Integrative
- Bounded
- Troublesome

(Land and Meyer, 2003)

Lecture activity: divergence theorem

- Please blow up your balloon a bit
- Then tell your neighbour what you estimate the volume is
- Any unit of measurement is ok – e.g.
    - half a pint?
    - 175 cl?
    - 330 ml?
    - ½ a litre?
    - 200 cm^3

Lecture activity: divergence theorem

- This is called the 'initial' volume estimate
- Linda's initial volume estimate $= 100\ ml$
- Try to remember yours
- Don't let go!

Lecture activity: divergence theorem

- Now blow again for exactly 3 seconds, and estimate the new volume
- This new estimate is called is the ‘final’ volume

Lecture activity: divergence theorem

- Linda's final volume is $1{,}000\ ml$
- What's yours?

Lecture activity: divergence theorem

- Question 1: How much did the balloon expand by?

- Hint: calculate the difference between the two volumes

- Linda's initial volume $= 100\ ml$
- Linda's final volume $= 1{,}000\ ml$
- Final – initial $= 1{,}000 - 100 = 900\ ml$

Lecture activity: divergence theorem

- Question 2: Now calculate the rate of expansion
- Hint: it's $\frac{the\ difference\ between\ the\ two\ volumes}{the\ time\ it\ took\ (3\ seconds)} = \frac{final - initial}{time}$
- Linda's rate $= \frac{1000-100}{3} = \frac{900}{3} = 300\ ml\ per\ second$
- What was your rate? (We are done with the balloons now ☺)

Question for students in the lecture….

- Question: How can you combine the six symbols below to represent mathematically what you just calculated, as a flux integral?

dS $\quad \boldsymbol{v}$ $\quad \boldsymbol{S}$ $\quad \oint$ $\quad \cdot$ $\quad \hat{\boldsymbol{n}}$

- Answer: $\oint_S \boldsymbol{v} \cdot \hat{\boldsymbol{n}} \, \mathrm{dS}$

- This is a major component of the divergence theorem $\int_V \nabla \cdot v \, \mathrm{dV} = \oint_S \boldsymbol{v} \cdot \hat{\boldsymbol{n}} \, \mathrm{dS}$

Question to you…

- Is this balloon lecture activity ‘discovery-based learning’?

PG Diploma in University Learning & Teaching assignment

Develop a narrative argument about both the relevancy and limitations of ‘Threshold Concepts Theory’ when applied to your educational setting

I discovered that the divergence theorem is a *threshold concept in my teaching*

Discovery-based Learning Pushes Students Over the Threshold……Thank you for listening

- Balloon lecture activity: not discovery–based learning
  - relating an actual object to mathematical symbols $\int_V \boldsymbol{\nabla} \cdot \boldsymbol{v}\, \mathrm{dV} = \oint_S \boldsymbol{v} \cdot \hat{\boldsymbol{n}}\, \mathrm{dS}$
  - the social interaction

- PGDip 'writing critically' assignment: discovery-based elements
  - critical writing skills
  - threshold concept theory
  - I discovered a threshold concept in my teaching,
  - and consequently designed the balloon activity to scaffold crossing the threshold