



Categorizing Students' Use of Differential Resources in Physics Integration Problems

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1. MOTIVATION

- Students encountered a lot of difficulties with setting up integrals in physics problems, especially Interpreting differentials (or infinitesimals).[1,2,3,4]
- Our aim is to understand students' solutions and mistakes from the resources perspective. [5]

2. RESEARCH QUESTION

What mathematics and physics resources do students activate associated with the understanding of differentials in a given context?

3. METHODOLOGY

- 13 students from second-semester calculus-based introductory physics
- Semi-structured group interviews
- Students worked in groups of 2 or 3 with whiteboards
- Eight interview sessions with 1 hour and 15 min each
- Interview protocols: physics integration problems in electricity & magnetism
- Data analysis is based on the first interview session and the context is to find the electric field due to a bar of charge with constant charge distribution

REFERENCES

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4. RESOURCES USED ASSOCIATED WITH DIFFERENTIALS

Resources	Description	Example Quotes
a small amount	a small amount or a tiny bit of a physical quantity, e.g., a small amount of charge	<i>Explaining dE and dq:</i> “Well, since this is just the value that a particular line segment is putting on to our P, then that would only be a tiny segment of the charge , which is what we described as dq.” “We have a charge Q over the entire length of L, so this is just saying when you have a little piece ...So then it is just a ratio of a whole charge over the whole length to a little bit of charge over a little bit of length .”
a point	a point quantity or quantity of a point, e.g., a point charge	<i>Explaining dq:</i> “The charge at every single point is charge divided by the distance ... just the charge density, is that what it means? “ “Basically, the point charge is at each point along L, is the total charge over its length...”
something changing	indication of a quantity that is changing without physical meanings	<i>Explaining dq and dx:</i> “...you don't need dq, since there is not more charge ...” “Our q is not changing throughout the length, cause it's uniform. So we shouldn't need to integrate q. I didn't think.”
taking derivative	taking derivative of a quantity	<i>Explaining dq and dx:</i> “We are taking the derivative of length dx. To do that, you change the charge, which is ... you have charge density which is Q/L, for that section.”

5. CONCLUSION AND IMPLICATION

- The conceptual resources used by students associated with differentials are a small amount, a point, something changing, and taking derivative.
 - “A small amount” resource is close to what physicists often use;
 - “A point” resource could lead to students' difficulties when setting up integrals as a point often has no dimensions;
 - “Something changing” resource is often misapplied by students when they decide the variable of integration;
 - “Taking derivative” resource could prevent students from obtaining a conceptual understanding of math and physics concepts.