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

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	*Explaining dE and dq:* "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	*Explaining dq:* "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	*Explaining dq and dx:* "…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	*Explaining dq and dx:* "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."

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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.