

# Students' Understanding of Taylor Series in Electricity and Magnetism

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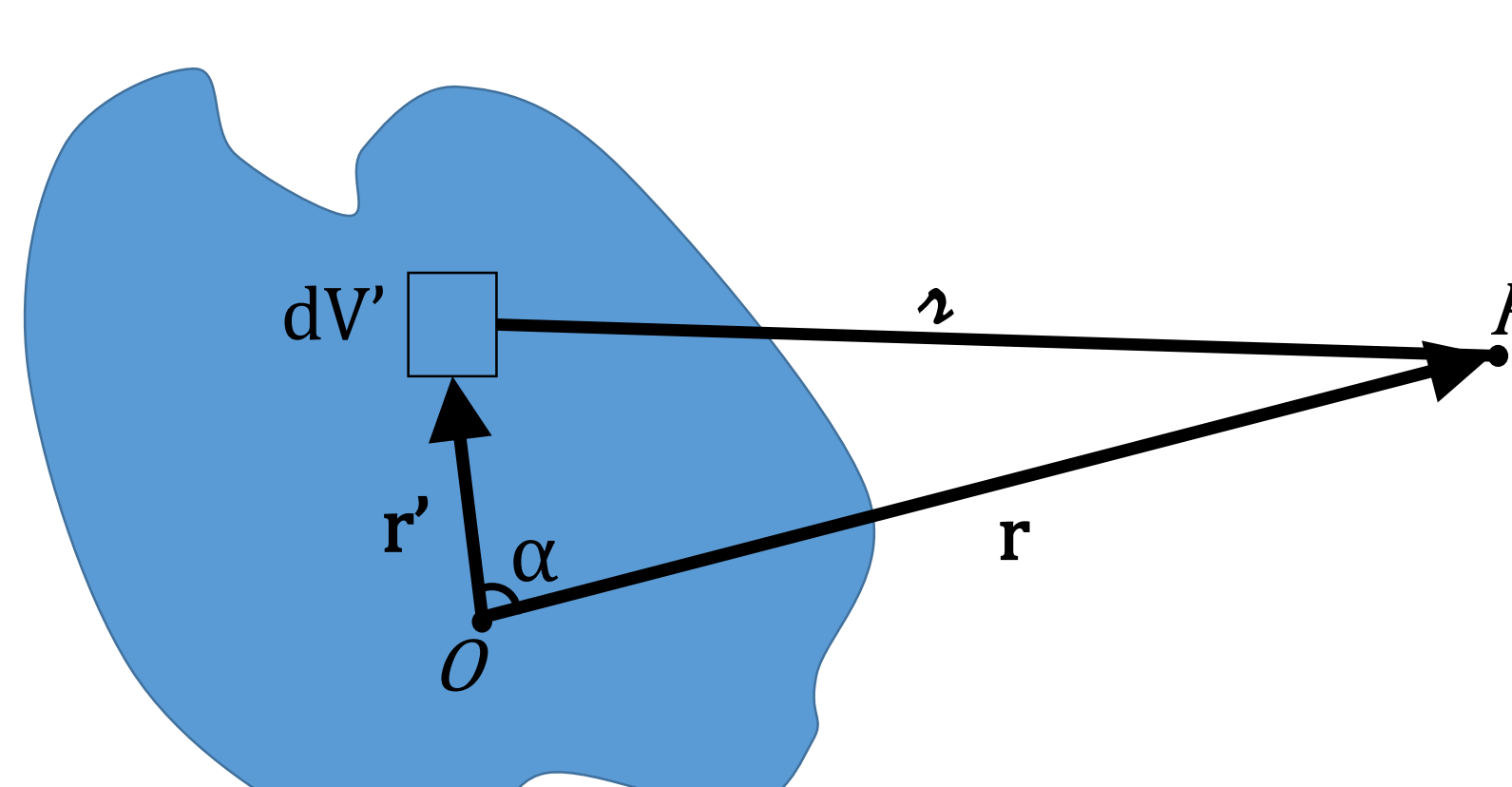


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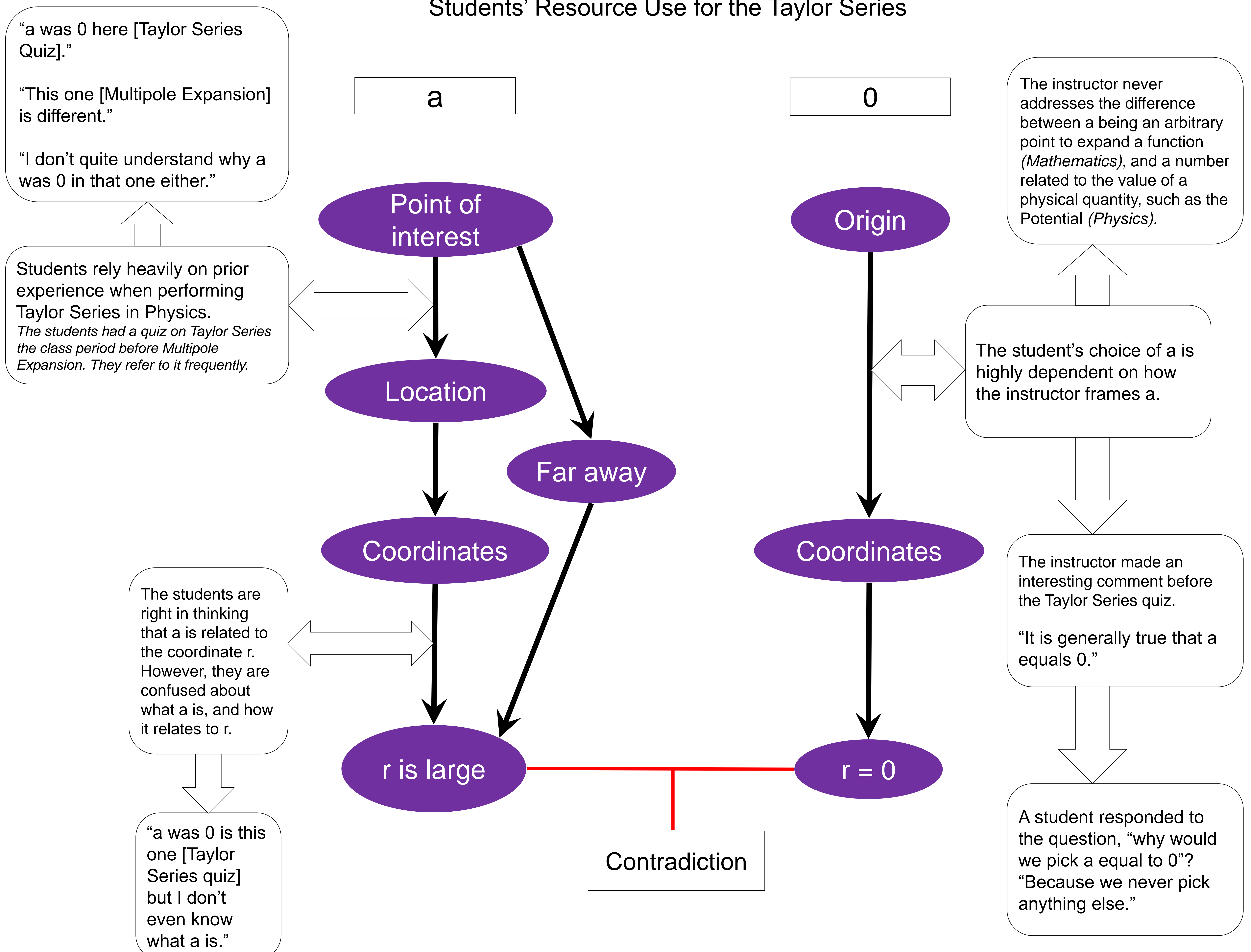


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Context	Task	Solution	Resources Framework
<ul style="list-style-type: none"> <li>Junior level Electricity &amp; Magnetism I</li> <li>16 students</li> <li>4 groups of 4 students</li> <li>Groups collaborate to solve problems in lecture</li> <li>The lecture covers Taylor Series in weeks 3 &amp; 4</li> </ul>	<p>Find the Multipole Expansion for the potential of any localized charge distribution in terms of powers of <math>\frac{1}{r}</math>.</p>  <p><small>Original Image: Griffiths Introduction to Electrodynamics 4th Ed. Figure 3.28</small></p>	<p><b>Part A (Done by instructor)</b></p> <p>Write <math>\lambda</math> in terms of <math>r</math> and <math>r'</math> using Law of Cosines. <math>\lambda^2 = r^2 + (r')^2 - 2rr'\cos\alpha</math></p> <p>Factor a <math>r^2</math> term out of the above expression. <math>\lambda^2 = r^2(1 + (\frac{r'}{r})^2 - 2\frac{r'}{r}\cos\alpha)</math></p> <p>Set <math>\lambda = \sqrt{1 + \epsilon}</math> where <math>\epsilon = (\frac{r'}{r})^2 - 2\frac{r'}{r}\cos\alpha</math></p> <p>Taylor Expand the expression <math>\frac{1}{r}(1 + \epsilon)^{-1/2}</math> with respect to <math>\epsilon</math>.</p> <p><b>Part B (Done by students)</b></p> <p>The Taylor Series <math>f(x) = \sum_{n=0}^{\infty} \frac{d^n f(a)}{dx^n} \frac{(x-a)^n}{n!}</math></p> <p>Determine a Assuming, <math>P</math> is "far away," <math>\frac{r'}{r} \approx 0</math>, so we can take a = 0.</p> <p><math>f(\epsilon) \approx \frac{1}{r}(1 - \frac{1}{2}\epsilon + \frac{3}{8}\epsilon^2)</math></p>	<p>To explain the students' thought process, we employ the Resources Framework.</p> <p>A Resource is "a chunk of knowledge that students bring to bear on a situation."<sup>1</sup></p> <p>We arrange the resources into a resource graph<sup>2</sup> to illustrate the student's thought process.</p>
<p><b>Methodology</b></p> <ul style="list-style-type: none"> <li>Our observations are based on emergent claims</li> <li>We employ video-based microanalysis of intra-group conversation</li> <li>Data is taken from 2 of the 4 groups</li> </ul>			

## Students' Resource Use for the Taylor Series



References:  
<sup>1</sup>(K. Black, M. C. Wittmann 2009)  
<sup>2</sup>(M. C. Wittmann 2006)