

When Too Little or Too Much Hurts: Evidence for a Curvilinear Relationship Between Inquiry-based Teaching and Student Achievement in Science

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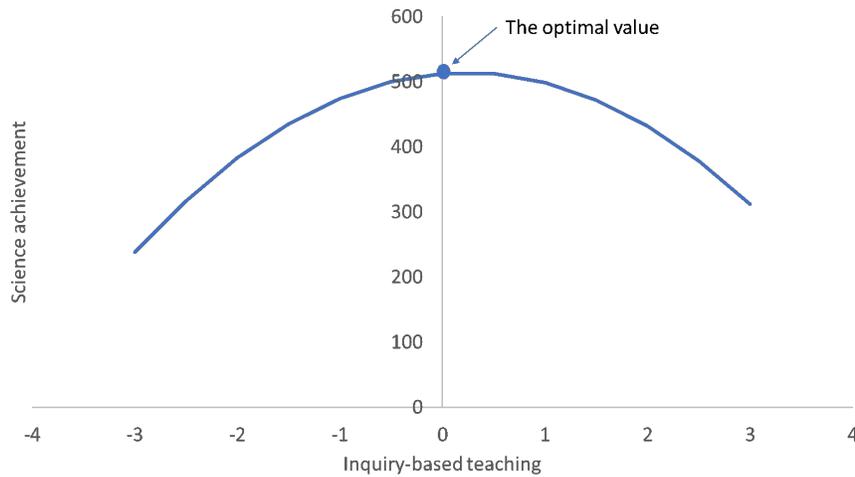
A growing body of research has investigated the effectiveness of inquiry-based teaching, such as by engaging students in conducting scientific experiments. Yet, this research abounds in conflicting findings: While some studies showed that this teaching approach is positively related to higher science achievement, others found negative or insignificant relations.

What may cause the inconsistent results?

This inconsistency might be associated with the nature of inquiry measure and the analysis of the resultant data. Most studies assessed inquiry-based teaching with *frequency* scales (i.e., how often specific inquiry activities occur) and assumed that a *linear* relation to student achievement existed. However, the latter assumption may be questionable: Implementing inquiry investigations requires ample lesson time, and over-emphasizing this approach might cut into time spent on other necessary teaching and learning practices. Hence, instead of assuming that “the more inquiry the better”, researchers investigating teaching effectiveness should consider the possibility of a *curvilinear* relationship.

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Fig. 1 The curvilinear relationship between inquiry-based teaching and science achievement.



Note. Inquiry-based teaching has a latent scale with a mean of zero. The scale from -4 to 4 is chosen arbitrarily.

How does inquiry relate to science achievement? Linear vs. curvilinear

To address this question, [our study](#)¹ analyzed a representative sample of Norwegian students in Grade 9 from the Trends in Mathematics and Science Study (TIMSS) 2015. It tested both linear and curvilinear models of the relationship between inquiry-based teaching and achievement at the classroom level. While a linear model resulted in an insignificant relationship, the curvilinear model showed a significant relationship following an inverted U-curve (see Figure 1). As a result, engaging in inquiry activities more frequently was associated with better achievement up until an optimal value. Science achievement decreased as the use of this teaching approach increased further.

The evidence of the curvilinear pattern in [this study](#)² challenges the linearity assumption on the effectiveness of inquiry-based teaching and contributes to explaining the inconsistent results in previous studies. Too few or too many inquiry activities in science classrooms may not be beneficial for student learning at all.

This finding also stimulated later studies, which could replicate the curvilinear relationship at different levels of analysis. For instance, [Cairns \(2019\)](#)³ found a curvilinear relationship between inquiry-based teaching and achievement at the country

¹ <https://doi.org/10.1016/j.learninstruc.2018.02.006>

² *Idem*

³ <http://dx.doi.org/10.1007/s11165-017-9639-x>

level across 69 countries participating in Programme for International Student Assessment (PISA) 2015, whereas other studies found similar results at the student level (e.g., [Oliver, McConney, & Woods-McConney, 2019](#)).

Implication for teaching effectiveness research

Few studies in teaching effectiveness research have considered the likely existence of curvilinear relationships between teaching factors and student outcomes. As shown in this study, two variables may not have a significant linear relationship, but they are in fact related in a curvilinear pattern. Therefore, researchers should consider the possibility of a curvilinear relationship in investigating teaching effectiveness. This investigation is crucial particularly for the studies that measure teaching factors using frequency aspect, such as in TIMSS and PISA.

This text has been posted on the blog [international-education.blog](#) and it is available in different languages on [international-education.blog](#)

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