The Journey of Quantitative Literacy Development: Insights from Physics Majors

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Recent studies have shown that students often struggle with mathematical concepts in introductory and upper division courses (Kuo, et al., 2013). The Physics Inventory of Quantitative Literacy (PIQL) is a 20-item multiple-choice test designed by White Brahmia, et al. to measure the development of physics quantitative literacy (PQL) across physics courses.

In this study, we aim to understand the development of quantitative reasoning as physics majors progress through their academic journey. We present research on PQL development of physics majors at a large public university, using the PIQL as a probe. In addition to characterizing student development quantitatively, we also analyze students' reflections about the development of quantitative reasoning in their physics courses. Our work was guided by the following research questions: How does PQL develop over time? How do students perceive collective PQL development as a result of their course-taking?

We share preliminary findings, using a mixed-methods approach. We triangulate a quantitative analysis of PIQL data with qualitative analysis of student responses – regarding evidence that PIQL scores barely improve in the introductory physics courses – to the following prompt, "Are you surprised by the outcome? Please write about your reaction to this finding".

The data was collected during multiple terms and covered introductory and upper-division physics courses. Our quantitative findings emerge from data sets of matched students who took the PIQL in at least two successive courses in subsequent years (e.g., 1st-2nd year, 2nd-3rd year), with the sample sizes ranging from 40-200 matched students. To better understand the experience of all students, we categorized matched sets of students into subgroups of low, medium, and high pre-test PIQL scores. In the qualitative study, we analyzed survey responses from the prompt above using a grounded theory approach (Glaser & Strauss, 1999), which was administered as part of a homework assignment that involved taking the PIQL.

The quantitative analysis used the normalized change as its primary metric to characterize the change in scores from pre-test to post-test (Marx & Cummings, 2007). Average PIQL scores improved mildly as students progressed through their major, but the improvement varied, with high-scoring students showing the most growth and low-scoring students making minimal gains, particularly in upper-division courses. The qualitative analysis characterized student perceptions of PQL development in introductory physics. Some students were surprised by their peers' slow progress, while many felt relieved and validated to see evidence of slow change. Those with lower initial scores expressed concerns about their slow progress and called for instructional improvements. Many were unsurprised that the development is slow, claiming that it isn't a learning objective in physics to improve quantitative reasoning.

Our findings suggest a potential relationship between the higher-performing physics majors and more significant PQL growth than their lower-performing peers. While the current study has its limitations, it may offer some initial insights into the challenges faced by physics majors in developing quantitative literacy. Further investigation with a larger dataset could help us explore these issues in more depth and potentially provide valuable insights for enhancing teaching strategies in both physics and mathematics education.

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