Challenges and Resources for Linguistically Diverse Students in Inquiry-Based Undergraduate Mathematics Curricula: The Case of Inquiry-Oriented Linear Algebra (IOLA) Tasks

Ernesto Daniel Calleros
San Diego State University & University of California San Diego

Keywords: Inquiry-Based Mathematics Education; Linear Algebra; Equity and Diversity

While there is consensus that inquiry-oriented (IO) instruction is a better alternative overall to lecturing (e.g., Laursen & Rasmussen, 2019), IO approaches may not be equitable for students from certain demographics (e.g., gender inequities in Reinholz et al., 2022). This analysis explores a question related to equity considering linguistic diversity: What linguistic challenges and resources do linguistically diverse undergraduate students experience in IOLA tasks?

Grounded in a sociocultural theory (e.g., Moschkovich, 2015), I constructed a framework that captures linguistic challenges and resources along three interrelated dimensions: (a) lexical – words and phrases in a task (e.g., Spanos et al., 1988), (b) situational – material, activity, semiotic, and sociocultural aspects of a task (e.g., Gee & Green, 1998), and (c) normative – social and sociomathematical norms engendered across tasks (e.g., Yackel et al., 2000).

The data analyzed were one-on-one semi-structured interviews (each lasting about 30-60 minutes) with 5 male linguistically diverse students from one IOLA course. The 5 students spanned a diverse range of cultural backgrounds (Korean, Vietnamese, Malaysian, Hispanic, and White) and comfort levels with English. In the interviews, each student was asked to arrange the first 12 mathematical tasks from their class from most to least challenging linguistically and to explain their ranking of each task. The tasks came from an expanded version of Wawro et al.'s (2013) IOLA curriculum. Each interview was analyzed task by task using the constant comparative method (Miles et al., 2020), allowing for both a priori codes and emergent codes.

Below are some of the main linguistic challenges and resources that students reported:

1. *Lexical:* Challenges included unfamiliar/unintended meanings of words in problem contexts, unfamiliar/unintended meanings of vector notation, and new mathematical terms; Resources included familiar words as well as translations and informal definitions of unfamiliar words and notation.
2. *Situational*: Challenges included high numbers of words and sub-questions, the exclusive use of English, the formality of definitions, symbolizing problem contexts, and algorithmatizing; Resources included low numbers of words and sub-questions, students' primary language(s), translation tools, visuals, and symbolic mathematical language that prompted specific procedures.
3. *Normative*: Challenges included violated expectations about the mathematical complexity level, a single "right" way to solve a task, and the prescription of generalized procedures.

In the presentation, further details will be provided about these findings, which suggest the need for pedagogical linguistic supports in task design and implementation that address and leverage the identified challenges and resources.

References

Gee, J. P., & Green, J. L. (1998). Discourse analysis, learning, and social practice: A methodological study. *Review of Research in Education, 23*(1), 119–169. https://doi.org/10.3102/0091732X023001119

Laursen, S., & Rasmussen, C. (2019). I on the prize: Inquiry approaches in undergraduate mathematics education. *International Journal of Research in Undergraduate Mathematics Education, 5*(1), 129–149. https://doi.org/10.1007/s40753-019-00085-6

Miles, M. B., Huberman, A. M., & Saldana, J. (2020). *Qualitative data analysis. A methods sourcebook* (4th ed.). Sage Publications.

Moschkovich, J. (2015). Academic literacy in mathematics for English Learners. *The Journal of Mathematical Behavior, 40*, 43–62. https://doi.org/10.1016/j.jmathb.2015.01.005

Reinholz, D., Johnson, E., Andrews-Larson, C., Stone-Johnstone, A., Smith, J., Mullins, B., Fortune, N., Keene, K., & Shah, N. (2022). When active learning is inequitable: Women's participation predicts gender inequities in mathematical performance. *Journal for Research in Mathematics Education, 53*(3), 204–226. https://doi.org/10.5951/jresematheduc-2020-0143

Spanos, G., Rodes, N. C., Dale, T. D., & Crandall, J. (1988). Linguistic features of mathematical problem solving: Insights and applications. In R. R. Cocking & J. P. Mestre (Eds.), *Linguistic and Cultural Influences on Learning Mathematics* (pp. 221–240). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203056820

Wawro, M., Zandieh, M., Rasmussen, C., & Andrews-Larson, C. (2013). Inquiry oriented linear algebra: Course materials. Available at http://iola.math.vt.edu. This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Yackel, E., Rasmussen, C., & King, K. (2000). Social and sociomathematical norms in an advanced undergraduate mathematics course. *The Journal of Mathematical Behavior, 19*(3), 275–287. https://doi.org/10.1016/S0732-3123(00)00051-1