Analysis of the Conditions and Constraints Shaping a Modelling-Based Course of Life Sciences

Garima Gogia
Texas State University

Jennifer A. Czocher
Texas State University

Keywords: mathematical modelling, anthropological theory of didactic, didactic transposition

Teaching mathematics to students in non-mathematics undergraduate programs remains a persistent challenge because of difficulties in engaging students with genuine problems and models from the disciplines they study (Barquero et al., 2013). Life Sciences is one of those disciplines where the role of mathematics in relation to genuine problems is often questioned (Cozzens & Roberts, 2020, p. 87; Garfinkel et al., 2022) despite its increasing relevance to biology, physiology, and other disciplines (Cozzens & Roberts, 2020). The sense of *applicationism* (Barquero et al., 2013) that runs through mathematics courses for life science majors is amplified by the perception that mathematics is not a tool for understanding biological phenomena. This situation calls for the creation of a course that can engage students from life sciences more meaningfully with mathematics, where mathematics takes on a role as an integrated discipline (Bosch et al., 2020).

One of the approaches to creating such a course was to focus on the biological themes that "resonate deeply with life science students" through "a mathematical framework for making simulating and analyzing dynamical models" (Garfinkel et al., 2022, p. 42). With a greater focus on modeling phenomena, this course stressed concepts like feedback loops, dynamical systems, and bifurcations through differential equations. It also included computer programming, defining derivative as a linear approximation to a point, and analyzing the stability of equilibrium points of single-variable differential equations (Garfinkel et al., 2017). To enroll in this course, life science students do not need calculus as a prerequisite.

A course is an empirical object. The Anthropological Theory of Didactic (ATD) allows us to question, model, describe, and analyze the didactic transposition of the knowledge of the course (Bosch et al., 2021). Didactic transposition is the process of selection, adaptation, organization, and declaration that shapes the knowledge to be taught within school institutions, including universities. The reasons that shape this knowledge can be located at the levels of codeterminacy (Chevellard, 2002). This brings us to our research question: *What conditions and constraints for didactic transposition contribute to shaping the modelling-based course? At what levels of the scale can these conditions and constraints be identified?*

To address this question, we present the genesis and shape of this modelling-based course for life sciences developed by a quantitative biologist at a large public university in the USA. Our account is informed by the course developer's retrospective interpretations of the process of production of the course. We use praxeological analysis to generate an in-depth account of mathematics in the modelling-based course. Comprising a practical (praxis) block and a theoretical (theory) block, praxeology for teaching (didactic praxeology) of the modelling-based course enables us to account and analyze the practical and theoretical nuances of the course. The reasons for the conditions and constraints that affect the production of the course are obtained from the levels of codeterminacy, providing empirical evidence for the dependence of the course on specific institutional factors (Bosch et al., 2020).

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 2417149.

References

Barquero, B., Bosch, M., & Gascón, J. (2013). The ecological dimension in the teaching of mathematical modelling at university. *Recherches en didactique des mathématiques, 33(3*), 307–338.

Bosch, M., Hausberger, T., Hochmuth, R., Kondratieva, M., & Winsløw, C. (2021). External didactic transposition in undergraduate mathematics. *International Journal of Research in Undergraduate Mathematics Education, 7(1)*, 140–162.

Bosch, M., & Winsløw, C. (2020). The external didactic transposition of mathematics at the university level: Dilemmas and challenges / La transposition didactique externe des mathématiques au niveau universitaire: Dilemmes et défis. Educação Matemática Pesquisa: Revista do Programa de Estudos Pós-Graduados em Educação Matemática, 22(4), 373–386.

Chevallard, Y. (2002). Organiser l'étude: 3. Ecologie & régulation. In J.-L. Dorier, M. Artaud, M. Artigue, R. Berthelot, & R. Floris (Coord.), *Actes de la XIe école d'été de didactique des mathématiques* (pp. 41–56). Grenoble: La Pensée sauvage.

Cozzens, M., & Roberts, F. S. (2020). Introductory college mathematics for the life sciences: has anything changed? *Bulletin of Mathematical Biology, 82(7)*, 87.

Garfinkel, A., Bennoun, S., Deeds, E., & Van Valkenburgh, B. (2022). Teaching dynamics to biology undergraduates: The UCLA experience. *Bulletin of Mathematical Biology, 84(3)*, 43.

Garfinkel, A., Shevtsov, J., & Guo, Y. (2017). *Modeling life: the mathematics of biological systems.* Springer International Publishing AG.