

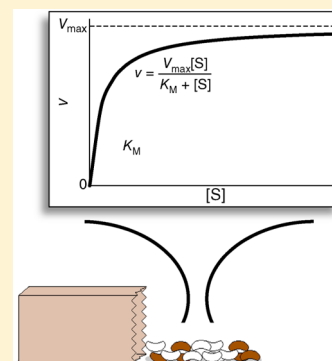
A Method for Teaching Enzyme Kinetics to Nonscience Majors

Glen Hinckley*

Department of Chemistry, Farmingdale State College, Farmingdale, New York 11735, United States

S Supporting Information

ABSTRACT: Enzyme kinetics is an essential part of any proper chemistry education, especially in health care fields such as nursing. Unfortunately, few quality methods for teaching the concepts to nonscience majors have yet been developed. Herein is described the modification of an existing active-learning teaching method with a conceptual basis for teaching enzyme kinetics to nonscience majors. The materials are readily available and the method is both facile and engaging.



KEYWORDS: First-Year Undergraduate/General, Second-Year Undergraduate, Biochemistry, Analogies/Transfer, Hands-On Learning/Manipulatives, Humor/Puzzles/Games, Bioanalytical Chemistry, Kinetic, Enzyme, Mechanisms of Reactions

A dilemma in teaching enzyme kinetics is the lack of teaching methods aimed at nonmajors. In science-major courses, emphasis is placed on the Michaelis–Menten mechanism and equation,^{1,2} as diagramed in Figure 1. This

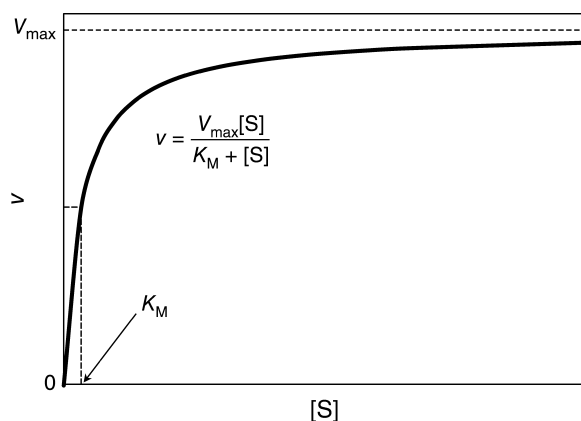


Figure 1. Typical plot of the Michaelis–Menten equation. In this diagram, K_M is given as 10.

equation is still exceptional at describing the principles of saturation and competitive inhibition, but it is unfortunately untenable for use with nonmajors who may not have the mathematics background necessary to interpret it. Even nontraditional teaching methods are currently geared toward science majors and may require some understanding of asymptotes and graphing of equations.^{3–8} The problem arises how to approach the topic with nonscience majors without utilizing sophisticated mathematics.

The theme underlying enzyme kinetics is more than an equation; the equation is simply the mathematical end point of the mechanism. The relationship between substrate concentration and rate of conversion is based on the enzyme's ability to locate and bind the substrate and the speed at which the enzyme can catalyze the substrate's conversion. Thus, the concept of enzyme catalysis could theoretically be divorced from the mathematics.

A recently developed, hands-on method for teaching enzyme kinetics provided the most reasonable approach to date. Runge et al. described a technique where students act as the enzyme: a student is blindfolded and attempts to transfer marbles from a “substrate” tub to a “product” tub.⁶ By varying the quantity of marbles, the students see how changing substrate levels affect the rate of conversion. Regardless of the authors' obvious aim toward science majors, the underlying structure was elegant enough to relay the basics of enzyme catalysis.

Herein is described a modification of the aforementioned activity tailored to a nonmajors chemistry course with a class size of 40–50 students. The new approach also uses materials and methods that are more cost-effective. Additionally, competitive inhibition is incorporated with a graspable analogy. Most importantly, the new approach is purely qualitative and does not require any significant mathematical training.

AUDIENCE AND INTRODUCTORY MATERIALS

The primary audience for the method was nursing students with varied chemistry experience ranging from high school chemistry to a single semester of college chemistry with half of a semester of introductory organic chemistry. None of the

Published: July 11, 2012

nursing students were expected to have completed mathematics beyond basic algebra and statistics for their major.

Because of the expectation of limited knowledge of chemical reaction rates, the students were first introduced to the concept of rates and rate acceleration by a series of simple mathematical exercises (available in Supporting Information). After definition of the terms “substrate” and “velocity”, the students were instructed on the activity for the session.

■ GAME SETUP

Students paired off for the game. Each pair of students was given a set of supplies (Table 1) and a set of rules. One student

Table 1. Materials Provided to Each Pair of Students

Bag	Number	Details	Contents
paper	1	26.5 cm × 13 cm × 9 cm	—
sandwich	1	small	50 dry northern beans (white beans)
sandwich	1	small	5 dry pinto beans (brown beans)

would act as the “enzyme” while the other student was a timekeeper. Starting with 5 white “substrate” beans in the bag, the timekeeper would keep track of 30 s intervals as the enzyme removed the beans one at a time. Once all beans were removed, or the 30 s had elapsed, the enzyme would stop removing beans and the students would tabulate the number of beans removed. The students repeated this process with an increasing number of substrate beans: 10, 15, 25, and 50 beans.

For a second round, a new twist was added: five brown “inhibitor” beans were added to the mixture. The brown beans could not be removed, and if the enzyme accidentally picked a brown bean, he or she would return it to the bag and continue. Bean removal again stopped at 30 s or when all the white substrate beans were removed from the bag. The same pattern of substrate beans (5, 10, 15, 25, and 50) was used for this round.

■ OBSERVATIONS

Generally the students were very well engaged in the procedure. The rules of the game were simple to grasp and most students adjusted easily to each added complexity, whether it be the additional substrate beans or the added inhibitor beans. The activity also provided a sense of comical frustration (especially when students pick a brown bean, only to realize that they must return it to the bag) and friendly competition. The competitive aspect was enhanced by asking students to report their results to the instructor, who then graphed the average data (shown in Figure 2) with the classroom projector. This also provided students with a visual demonstration of the saturation kinetics to be discussed and drew the students further into the procedure and the discussion. For the most part, students seemed well pleased with the experience. Assessment was also performed and is provided in Supporting Information.

■ SUMMARY

This demonstration of enzyme saturation and inhibition allowed for a more in-depth discussion of the significance of enzymes in chemistry and health science, and provided a

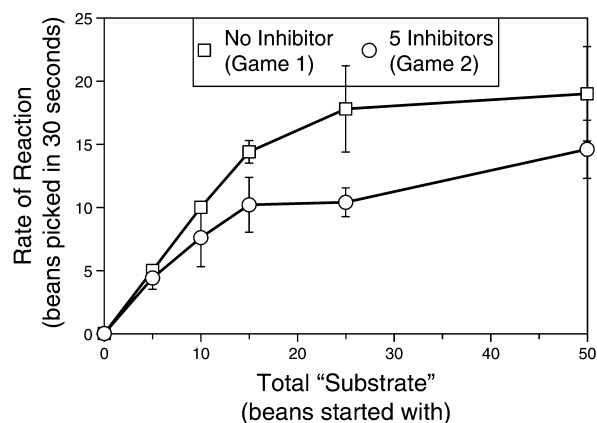


Figure 2. Graph of beans removed versus substrate beans included. Shown is a representative set of data that was collected in one class and averaged per each point. Error bars are given for one standard deviation of each averaged point. $N = 6$.

background to discuss real world examples of competitive inhibitors.

■ ASSOCIATED CONTENT

Supporting Information

Mathematical exercises used to introduce students to rates and rate acceleration; a summary of assessment goals, methods, and results. This material is available via the Internet at <http://pubs.acs.org>.

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: glen.hinckley@farmingdale.edu.

Notes

The authors declare no competing financial interest.

■ REFERENCES

- (1) Michaelis, L.; Menten, M. L. *Biochem. Z.* **1913**, *49*, 333–369.
- (2) Briggs, G. E.; Haldane, J. B. S. *Biochem. J.* **1925**, *19*, 338–339.
- (3) Lin, Y.; Lloyd, P. M. *J. Chem. Educ.* **2006**, *83*, 638–640.
- (4) Sorenson, R.; Novak, N. *Biochem. Educ.* **1996**, *24*, 26–28.
- (5) González-Cruz, J.; Rodríguez-Sotres, R.; Rodríguez-Penagos, M. *Biochem. Mol. Biol. Educ.* **2003**, *31*, 93–101.
- (6) Runge, S. W.; Hill, B. J. F.; Moran, W. M. *CBE Life Sci. Educ.* **2006**, *5*, 348–352.
- (7) Junker, M. *J. Chem. Educ.* **2010**, *87*, 294–295.
- (8) Abel, K. B.; Halenz, D. R. *J. Chem. Educ.* **1992**, *69*, 9.