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Laboratory Experiment

Developing Equitable Lab Practices/Culture: A Student-Centered Activity on Alcohol Metabolism and Its Relation to the Black Community

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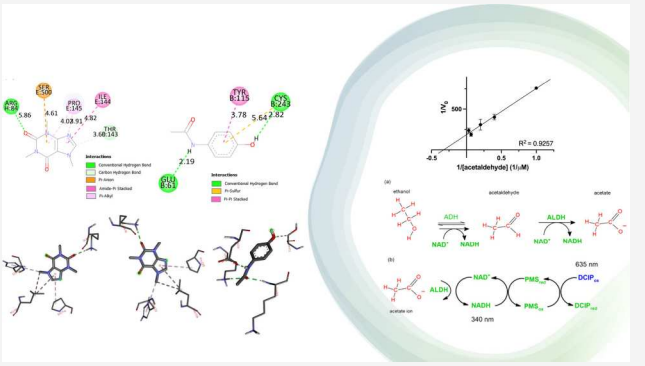
ABSTRACT: This lab updates the study of acetaldehyde oxidation in vitro using the enzyme aldehyde dehydrogenase (ALDH) by presenting the study in a guided inquiry approach that is culturally relevant. Acetaldehyde is a toxic compound that builds up in the liver following the consumption of alcohol, which must be metabolized. We used a spectrophotometer to follow the kinetics of this reaction, determine how substrate concentrations alter the rate of this enzymatic reaction, and screen potential enzyme inhibitors. Students are guided through questions that explore comparatively uncomplicated kinetic and thermodynamic theory that supports the reaction of enzyme catalysis. This inquiry approach was aided by three-dimensional structural models of the enzyme that were explored within the laboratory sessions, enhancing the arcane lab procedures and developing student skills in experimental design. Students can draw from their everyday life experiences based on their cultural norms and knowledge to choose experimental conditions within a provided list of options, such as the alcohol or the reaction inhibitor selection. This was accompanied by written reports and finalized by oral presentations to the class.



KEYWORDS: *Upper-Division Undergraduate, Physical Chemistry, Laboratory Instruction, Inquiry-Based/Discovery Learning, Alcohols, Aldehydes/Ketones, Enzymes, Kinetics, Cultural Relevance*

INTRODUCTION

Many students take at least one semester of physical chemistry to fulfill science degree requirements but may struggle to understand the main objective of the undergraduate physical chemistry laboratory: to develop observational and laboratory skills while connecting with theoretical models. The traditional laboratory approach gives students instrument exposure and analytical skills but may lead to the misconception that the physical chemistry lab is solely about accurate measurements rather than scientific inquiry. Our approach at a Historically Black College University (HBCU) aims to transform the traditional enzyme-catalyzed reaction of ethanol into a multiple-session, student-centered inquiry lab with added content linked to alcohol metabolism in the Black community.

The study of alcohol dehydrogenase (ADH) and aldehyde dehydrogenase (ALDH) enzymatic reactions prepares students to address real-life issues across scientific fields. The traditional lab focuses on steady-state kinetics and thermodynamic equilibrium models applied to ADH and ALDH enzymatic activity (biochemistry) revealed through UV−vis spectrophotometric data (instrumental analysis) obtained by careful analytical technique and has been included in the physical chemistry laboratory curriculum for decades.[1−3] Genetic variants of ADH and ALDH in Black communities differ in chemical structure and properties, providing a culturally relevant learning opportunity. To this end, the lab described here requires students to use their cultural knowledge to guide conceptual understanding of how the thermodynamic and chemical environment affects enzyme kinetics.[4−6]

Motivated in part by our continued efforts to infuse polymer content into physical chemistry courses,[7] we are updating the traditional kinetic experiment to an inquiry-based one with culturally relevant student-centered components. Our goals are to guide students through questions exploring the effects of an inhibitor on enzyme catalysis and to incorporate students' everyday life experiences and cultural knowledge into the experimental choices. Others have reported guided inquiry activities on enzyme kinetic studies[8,9] as well as visualizing the

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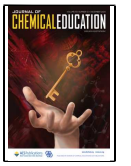

Table 1. Structure of Laboratory Activity

Module	Pre-experiment	Lab Practicum	Postlaboratory	
			Online	Offline
1: *Is alcohol metabolized differently in some Black individuals?*	Attend enzyme kinetics lecture and complete surveys	(a) Identify the roles of the ADH variant and their occurrence in Black communities. (b) Visualize the structures of the ADH isozymes	List issues that impact alcohol consumption in Black communities	Write one-page report
2: *What's the rate of alcohol metabolism?*	Answer inquiry questions	Measure basic Michaelis–Menten parameters (K_m, V_{max})	Graph and interpret data	Identify an inhibitor to evaluate
3: *Can soul food or drugs inhibit alcohol metabolism?*	Answer inquiry questions	(a) Remeasure Michaelis–Menten parameters with inhibitors present (b) Visualize the inhibitor to enzyme interaction	Graph and interpret data	Conduct surveys
4: *Is there a trend for alcohol use in Black communities?*	Prepare presentations from survey responses and one-page reports	(a) 4 minute presentations (b) Complete satisfaction surveys		

substrate and cofactor interactions within the ADH active site residues.[10] The laboratory experiment presented here is based on educational principles and best practices from previously published works. Our update also incorporates a modular approach to guided inquiry experimentation, utilizing 3D structural models of the enzyme during laboratory sessions to investigate enzyme kinetics. This approach, coupled with the other insightful precedents, aims to make the learning experiences more engaging and effective. The modular design of the experiment allows for partial implementation, making it adaptable to varying delivery times within the laboratory course. This approach is supported by literature linking student engagement, particularly among Black students, to increased racial and ethnic pride and belonging, thereby enhancing the personal relevance and effectiveness of their learning experiences.[11] To our knowledge, the results and student understanding of enzyme-catalyzed reactions have not been published from the culturally relevant viewpoint of Black communities.

LEARNING OBJECTIVES

The pedagogical goals for the experiment described here are threefold:

- *Culturally Relevant Problem Solving.* Students will engage with a culturally relevant problem that reflects real-world contexts, allowing them to explore a reaction with complex kinetics.
- *Data Acquisition and Analytical Skills.* Students will develop hands-on skills in UV–vis spectroscopy by collecting and analyzing experimental data. They will learn to fit these data to formulas derived from basic kinetic equations, enhancing their understanding of both the technique and the underlying scientific concepts.
- *Interpretation and Discussion of the Results.* Students will critically discuss the physical meaning of their results, encouraging them to articulate scientific concepts and explore the broader implications of their findings. This dialogue promotes deeper comprehension and helps students to appreciate the relevance of kinetics in various contexts. This approach fosters critical thinking and enables students to connect scientific principles to their own experiences and communities.

OVERVIEW

Our activity builds on students' knowledge of equilibrium and reaction rates from introductory chemistry courses. It involves the oxidation of ethanol to acetaldehyde by ADH in the presence of NAD (Figures SI-SH-1 and SI-IG-1). The work of Phillips, Jones, and Iski offers valuable insights for instructors.[9] Additional theoretical details and solution preparations are available in standard textbook presentations of the experiment.[3] Table 1 presents the 4-week project. Students work in groups of two or three, guided by materials provided through the course's Learning Management System. Each week features a focus question, a lab practicum, and online data analysis sessions. While attendance at weekly online sessions was encouraged, it was not mandatory. In the final week, students present their work, perform lab cleanup, and complete a satisfaction survey with data submitted electronically. This revised experiment fosters discussion among students, helping them connect with their cultural norms at an HBCU while developing a toolkit to understand the oxidation of ethanol by ADH/ALDH. Notably, this approach presents a culturally relevant framework that has been absent in previous experiments on this system.

Module 1: Is Alcohol Metabolized Differently in Some Black Individuals?

During the first pre-experiment session, the instructor covers Michaelis–Menten kinetics (Figures SI-SH-2 and SI-IG-2) and introduces the 4 week project. Students then submit their responses to a pre-experiment perceived skills questionnaire. The lab practicum begins with students grouped to explore data from the "1000 Genomes" Project (Figures SI-SH-3 and SI-IG-3), focusing on the distribution of ADH variants among different ethnic populations (Tables SI-SH-1 and SI-IG-1) and their kinetic properties (Tables SI-SH-2 and SI-IG-2).[5,6] Discussions reveal the association of different *ADH1B* gene variations with alcohol metabolism responses, particularly the high prevalence of the *ADH1B**3 gene in Black individuals.[11,12] Students also comment on a simplified visual of alcohol metabolism (Figures SI-SH-4 and SI-IG-4). The experiment could be adjusted to explore other ethnic populations and their distributions of ADH1B and ADH1C alleles

Under the guidance of a faculty member, student pairs explore the structures of ADH/ALDH obtained from the RCSB Protein Data Bank (PDB). One student group examines the diagrams of ADH, focusing on the wireframe and ball-and-stick diagram view of the active site with a catalytic Zn ion, and the other group studies the 3D structure of the active ALDH. The faculty member engages the students by asking basic questions to facilitate interactive learning and encourages them

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to note their findings. Students visualized the interactive sites as well as the number of α-helix subunits in PyMOL software, which is a popular molecular visualization tool that can load and display the docked poses of ALDH from AutoDock Vina. Another student group examined the PDB file of ALDH and documented their observations on the 3D structure of the active site.

Both groups share their findings of the structure−function differences in the isoenzyme variants during the synchronous online postlaboratory session. They examine graphs showing alcohol consumption by ethnicity and list factors influencing alcohol use in the Black community (Figure SI-IG-5). This list, shown in Table SI-IG-3, guides postexperiment homework. Students select topics from the list and summarize them in a one-page report. This exercise connects to real alcohol-related issues in the Black community and enhances their scientific and research skills (see Tables SI-SH-3 and SI-IG-3)

Module 2: What's the Rate of Alcohol Metabolism?

The pre-experiment questions are addressed in groups to help the students focus on key enzyme kinetic equations before starting the lab practicum. The lab practicum starts with a simple procedural handout that serves as a framework to guide a pair of students in designing a chemical kinetics experiment to test the enzymatic reaction. Stock solutions are prepared prior to the lab to save time. However, instructors may choose to expand the module to include pipetting and buffer preparation, guiding students through necessary calculations. Students work in pairs to measure ALDH enzymatic activity, create Lineweaver−Burk plots, and monitor how varying enzyme concentrations affect reaction rates. Our UV−vis studies use a compact, low-cost spectrometer with limited resolution, taking readings at 600 nm, a wavelength confirmed in control runs to show acceptable changes in the λ_{max} readings. This experiment was largely based on previous laboratory activities assessing the enzymatic activity of ADH[1,13] but focused on the next step in alcohol metabolism to provide more insight into ALDH genetic variants in populations. However, these activities would likely be just as effective using the original ADH laboratory activities if instructors so desired

Students use the synchronous online postlaboratory session to obtain guidance on constructing linear and nonlinear Michaelis−Menten plots as well as a linearized double-reciprocal Lineweaver−Burk plot. From this latter plot, the K_M and V_{max} parameters provide the first estimate for the Michaelis−Menten equation. Our students are guided in the use of Excel SOLVER to refine the K_M and V_{max} estimates, obtaining the best curve fit of the nonlinear Michaelis−Menten equation to the data. Typical data collected by a single student pair are presented in Figure 1. By using the hyperbolically saturated Michaelis−Menten plot to extract the K_M and V_{max} parameters (rather than the double-reciprocal linear regression), students obtain a statistically better fit of the data, as has been shown in the literature.[13]

At the end of the experiment, students reconnect with the cultural aspects of the lab and their relation to ALDH-catalyzed kinetics. One student volunteer offers the response that slower ethanol metabolism could lead to excessive acetaldehyde buildup in the blood, while another links this buildup to hangover symptoms. The instructor prompts further questions to investigate potential causes, leading the group to conclude that an inhibitor might compete for ALDH, slowing

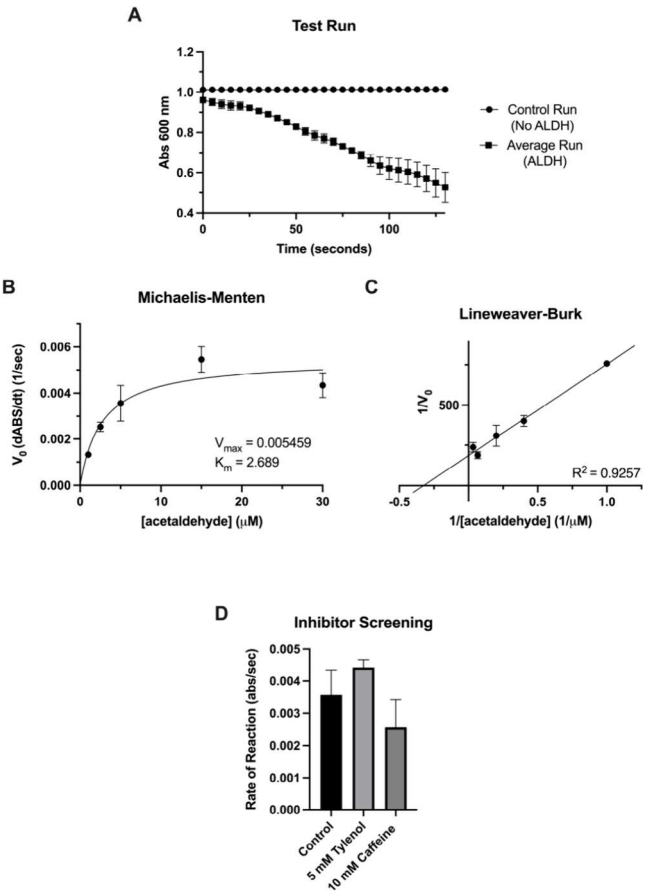

Figure 1. Student Data. (A) Test run of ALDH enzymatic reaction. The x axis represents the time in seconds, and the y axis represents the absorbance values at 600 nm. Circle data points represent a control run wherein no enzyme was added to the reaction, and square data points represent a test run where enzyme was added. (B) Michaelis−Menten curve generated from student data. The x axis represents the acetaldehyde concentration (μM), and the y axis represents the reaction rate as a change in absorbance over a change in time. (C) Lineweaver−Burk plot, where the x axis represents the reciprocal acetaldehyde concentration and the y axis represents the reciprocal reaction rate. (D) Reaction rates following incubation with Tylenol or caffeine. All bars represent the standard error.

alcohol metabolism. Instructors conclude the module with a homework assignment to identify soul foods or "grandma" remedies for hangovers.

Students select compounds from literature articles in the course Dropbox folder focusing on inhibitors from traditional African medicines,[14,15] soul food,[16] and over-the-counter medicines.[17,18] Initially, Tylenol and caffeine were chosen for the in vitro assay screening. We hypothesize that these compounds were selected because they were readily named in the titles of the provided reference literature. This eliminated the need for students to read through the longer review articles provided and submit the name of an inhibitor to screen. During subsequent semesters, kudzu, aloe vera, iboga, and catnip were added. We encourage the retention of the original inhibitor choices to refine and test our protocol. The chosen inhibitors are emailed to TAs and faculty at least 6 days before the inhibition study for approval. They must meet certain criteria: (1) commercially available or readily available in the lab and (2) spectrophotometrically monitorable. Students review papers to determine suitable inhibitor concentrations.

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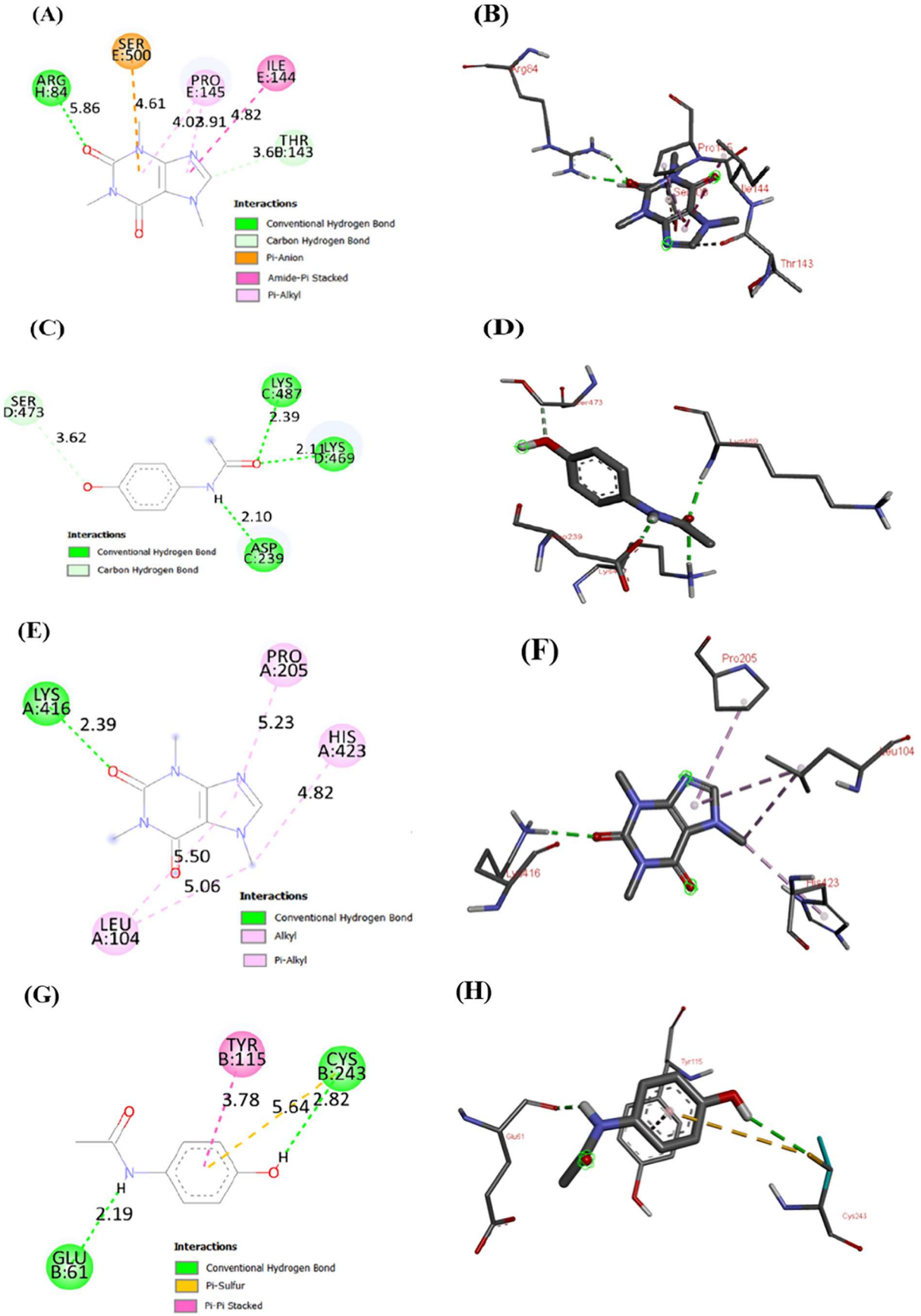

Figure 2. (A) 2D view of 3INL−caffeine; (B) 3D view of 3INL−caffeine; (C) 2D view of 3INL−Tylenol; (D) 3D view of 3INL−Tylenol; (E) 2D view of 3SZA−caffeine; (F) 3D view of 3SZA−caffeine; (G) 2D view of 3SZA−Tylenol; (H) 3D view of 3SZA−Tylenol.

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Instructors may opt to use only Modules 1 and 2 (adapted for a specific cultural component)[19,20] to obtain Michaelis–Menten kinetic data for a more focused physical chemistry or interdisciplinary course. The modular structure offers flexibility in implementation. For instance, a biology course at our HBCU adopted a modified version of Module 1 and demonstrated learning gains, as detailed in the Supporting Information.

Module 3: Can Soul Food or Medicines Inhibit Alcohol Metabolism?

Students begin by testing the inhibitor that they selected from a group of inhibitors identified in their literature review the previous week. The pre-experiment questions are addressed before students experimentally test the predicted inhibitor concentration. Our students identified Tylenol and caffeine as inhibitor choices during the pilot implementation stage, and these choices were retained throughout all of the subsequent implementation stages. The lab practicum is conducted in the same two student groups as in the previous week. They predict an ideal substrate concentration of 2 μM and confirm with the instructor that the range of 0–4 μM is appropriate before starting the inhibitor study. Representative plots of the student data are displayed in Figure 1. In this module, students test "patient" samples to assess deficiencies in metabolizing acetaldehyde using various dilutions of crude cell extract containing the enzyme. Representative plots of the test patient student data are included in Figure SI-IG-7. Students are asked to visualize the binding interaction between the inhibitor drugs they selected (i.e., caffeine and Tylenol) and the active site of ALDH. This task is led by a faculty member using the PDB and the software AutoDock Vina as described in the Supporting Information (see Table SI.1). The bulk of autodocking is performed by the instructor before lab. In the presence of the students, the instructor shows them how the software works and how the protein structure is run on the software by removing the water molecules to ensure accurate docking results. Students can see that both Tylenol (i.e., acetaminophen) and caffeine are good binding ligands for ALDH.

The 3D stereodiagrams and planar view of substrate-binding sites of the ALDH2*2 allele (PDB ID 3INL) with caffeine (see Figure 2A,B) show hydrogen-bonding interactions between caffeine and ARG84 with bond lengths of 2.13 and 2.25 Å. The binding energy is computed to be −7.2 kJ/mol. The 3INL–acetaminophen stereodiagrams show hydrogen-bonding interactions between the drug and amino acids within the active site: ASP239 with a bond length of 2.10 Å (Figure 2C,D) and LYS487, LYS469 having bond lengths equal to 2.38 and 2.10 Å. The binding energy is computed to be −6.3 kJ/mol. The 3D stereodiagrams and planar view of substrate-binding sites of the ALDH3A1 variant (PDB ID 3SZA) with caffeine and acetaminophen are also observed. For 3SZA–caffeine (Figure 2E,F), a hydrogen-bonding interaction is observed with LYS416 having a bond length equal to 2.38 Å and binding energy equal to −6.1 kJ/mol, while for 3SZA–acetaminophen (Figure 2G,H), hydrogen bonding is noticed for CYS243, and the binding energy is computed to be −6.3 kJ/mol. The binding energies are found to be similar for 3SZA–acetaminophen and 3INL–acetaminophen, whereas the 3SZA–caffeine and 3INL–caffeine show a minor difference of 1.1 kJ/mol, suggesting that binding strengths with different amino acids in the two drugs were similar. The estimated binding energies obtained from the docking studies are presented in Table S-1. The results confirm that conventional hydrogen bonding is dominant in the binding process, which causes a higher binding energy.

The postlaboratory session is dedicated to data analysis. As a final homework activity for this module, an alcohol consumption survey is designed with student input during the virtual postexperiment session. Students are asked to collect responses from their family and friends on their alcohol consumption trends. The alcohol consumption survey questions are provided in Table S.2

Module 4: Are There Trends in Alcohol Consumption in Black Communities?

The final class is devoted to oral presentations and satisfaction surveys. In the pre-experiment session, students prepare 4 minute presentations to share the results of their alcohol consumption surveys of family and friends as well as summarize their one-page reports that were prepared after Module 1. The students are advised to follow these guidelines for developing their PowerPoint presentations: limit the number of slides to a maximum of three, emphasize up to three conclusion sentences from the one-page reports, and present the survey data results in tabular format.

The lab practicum of this module starts with each student giving a 4 minute presentation. Many of the students are nervous about speaking in front of the class and the instructors. The three-slide requirement is not overwhelming and ensures that everyone can present and engage in a lively, student-led discussion. Students are knowledgeable and able to clearly articulate the social injustice issues they researched surrounding alcohol and its link to the Black community. A representative list of student comments (provided from their one-page summaries and highlighted in their 4 minute presentations) is shown in Tables SI-SH-3 and SI-IG-3. Oral presentations offer valuable experience in articulating and defending ideas in real time, boosting students' confidence in communicating scientific concepts. Students also find these presentations beneficial for their professional development, as reflected in the postlaboratory perceived learning skills questionnaire results (see below).

The survey data from family and friends are included in the 4 minute presentations, with results summarized in the Supporting Information. Men show a preference for consuming more liquor than women, highlighting significant gender differences in alcohol consumption patterns, including a higher mean volume for men.[21−27]

HAZARDS

Acetaldehyde is a highly flammable liquid and vapor that may cause irritation if inhaled. Appropriate PPE, including goggles and gloves, should be worn, and the chemical should be used in a chemical hood. Waste must not enter drains and should be disposed of according to national and local regulations.

IMPLEMENTATION AND INFRASTRUCTURE

This experimental approach was developed by faculty in collaboration with two graduate teaching assistants (TAs). Details about the TAs' training and their role in supporting the activity are provided below. Our target audience is students at North Carolina Central University (NCCU) enrolled in the first half of a two-semester introductory physical chemistry course, which includes coenrollment in weekly lectures, a 50

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minute recitation, and a 170 minute laboratory. The last two components of the course are used for 4 weeks to implement the described experiment. Additionally, two lectures focus on Michaelis−Menten and associated kinetic equations. This multiweek experiment was delivered three times between 2021 and 2022 to a total of 15 students. Across all iterations and refinement cycles, the goals of the experiment remained the same: provide students with a culturally relevant real-world problem and framework to relate to an experimental system with complicated kinetic mechanism, acquire and process data, and present the results.

The class size ranges between 5 and 12 students; however, for the three semesters we implemented this activity, the class enrollment was five students per semester. The participating students were 84% Black and classified as undergraduate juniors or seniors. Although the target audience for this kinetic project is students at an HBCU, the laboratory can be modified to appeal to students at various institutions. For example, ADH isoenzymes predominately occur in Native Americans (ADH1−7 and ALDH2),[28] Hispanics, Africans,[29] East Asians,[30] and Europeans.[31] The instructor should investigate specific modifications to adapt the laboratory project.[31,32] Laboratory activities take place in a dedicated physical chemistry lab with a UV−vis spectrophotometer. Students use the departmental conference room for the online components of the experiment. The main equipment required for the protocol is a computer and a UV−vis spectrometer.

Teaching Assistants

The TAs assigned to work with faculty on this project are graduate students enrolled in doctoral programs at predominantly white institutions. One TA guides the pre-experiment and lab practicum components each of the 4 weeks of implementation. The other TA guides the weekly virtual component offerings. Both TAs have previously participated in professional development for effective instruction (at their respective institutions). Their passion for undergraduate teaching is key to their selection in supporting the delivery and assessment of this culturally relevant enzyme kinetic laboratory activity at an HBCU. Two virtual meetings are held for the TAs and faculty instructors to address pedagogy, best practices, and instructional strategies underlying the 4 week project. Other meetings are held virtually on an as-needed basis

■ ASSESSMENT

This updated enzyme kinetics laboratory aims to guide students through an experiment with culturally relevant real-world applications. We expect students to enhance their laboratory skills, written and oral communication, critical thinking, and chemistry knowledge. They gain experience in UV−vis spectrophotometry while practicing scientific communication. Typically, 60% of students advance to the second half of the physical chemistry sequence, showing improvements in data analysis and oral presentations. Observations and survey results indicate that students met the learning outcomes of the experiment. All evaluation activities were conducted with Institutional Review Board approval (IRB #121309) and in compliance with their policies. The evaluations were conducted as a required class activity. However, students were informed that declining to give consent to include their work in the published data would not affect their academic progress. Written consent was gathered at the beginning of the laboratory activity.

Quizzes are designed to assess student learning gains and consist of 10 multiple-choice questions, ranging from basic knowledge to higher-level skills in interpreting kinetics data. Students are contacted via email to participate in the assessment, and a monetary lottery is used as an incentive.

Out of the 24 students contacted, 10 formed our two comparison groups: Enzyme Kinetics Informed Respondents and Retrospective Post-Project Respondents. The first group included five chemistry majors classified as juniors/seniors who completed courses that cover enzyme kinetics but not our 4 week project. The Retrospective Postproject Respondents completed all four modules of our enzyme kinetics project while enrolled in a physical chemistry course between 2021 and 2022. Both groups were allotted 3 minutes and 20 seconds to submit responses to the same 10 questions (Tables SI-IG-4 and SI-SH-4).

The mean score between the two groups improved from 48% to 70% of the questions being answered correctly with a decrease in standard deviation (0.20 and 0.07, respectively) (Figure 3). We realize the limitations of interpreting these results. Nevertheless, we find encouragement from a similar improvement trend observed in an adapted version of Module 1 (see Figure SI-IG-6.). An in-person quiz containing five questions of mixed format was administered to biology students before and after conducting an adapted version of Module 1 during a single 3 hour laboratory session. The average class mean improved from 22.4% to 88.8% of the questions being answered correctly. Full details of those results are provided in Table S.3. Taken together, the results from our assessment and evaluation suggest that student knowledge increased when students were exposed to this enzyme kinetic project.

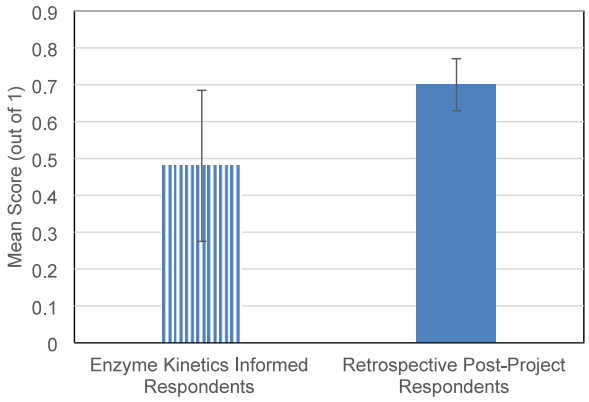

Figure 3. Mean quiz scores of a retrospective postproject student group compared to the mean scores of a student group unfamiliar with our 4-week kinetic module but knowledgeable about enzyme kinetics. Note: The improvement in learning and retention of scientific content is corroborated by pre- and postproject mean scores of a condensed version of our guided inquiry project (see Figure SI-IG-6).

During each 4 minute presentation, students take careful notes focusing on the scientific merits of the work being presented. They then discuss the experiment, suggest improvements, and reflect on what they learned. Anecdotal observations and student self-assessments indicate learning gains.

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Pre- and postsatisfaction surveys evaluated students' experiences during the 4 week project. The surveys included 11 closed-ended Likert scale questions assessing skill levels before and after the experiment. The results indicate that students felt they gained technical and soft skills, although some, such as delivering oral presentations using PowerPoint, were rated as declining (see Table S.3). Students noted that this experience offered opportunities not typically found in traditional science courses.

Postsatisfaction surveys ask students to rank their experiences with a 4 week project, assessing confidence levels and self-reported learning gains. A similar survey at the beginning of Module 1 gathers participants' perceived technical and soft skills related to chemistry. The postsurvey includes 11 closed-ended Likert scale questions, prompting students to rerate their skills after the experiment, with ratings from 1 (very weak knowledge) to 5 (very strong knowledge). Overall, students reported improved understanding of the necessary technical skills along with gains in both technical and soft skills. However, some soft skills, such as delivering PowerPoint presentations, were rated as declining from pre- to postexperiment. Students found this experience to be a valuable opportunity not typically available in traditional science courses.

CONCLUSIONS

A guided-inquiry experiment on ALDH-catalyzed metabolism of acetaldehyde and inhibitor screening is described here with updated components of molecular docking visualizations and culturally relevant interpretation of data that foster student engagement at our HBCU. This interdisciplinary experiment can be adapted to a biochemistry laboratory course and made inclusive of diverse student populations. Students can be primed to meet lab objectives more effectively when examples are drawn from real-world scenarios presented in a culturally relevant framework.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.4c00346.

Student handout, instructor guide, and supplemental tables of binding energies and survey results (PDF, DOCX)

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Author Contributions

U.R. contributed to the graphic designs, stereodiagrams using autodocking software, and critical evaluation of the paper content. D.K. authored all of the experimental procedures. S.C.S.K. developed the Module 1 student handout. D.K.T. authored the manuscript with assistance from all the listed coauthors. R.R.K. delivered all the postexperiment virtual content.

Notes

The authors declare no competing financial interest.

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