TEACHING FOOD PROCESSING TO CHEMICAL ENGINEERING STUDENTS WITH NATIVE AMERICAN FOOD

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INTRODUCTION

Besides being one of the most popular career choices among chemical engineering students [1] food industry examples are also an elegant approach to show students the application of fundamental chemical engineering equations since they relate complex concepts to familiar examples. Intriguingly, a content review has indicated that only a few institutions offer an elective course on food science/engineering for chemical engineering majors. In South America and Asian countries, this phenomenon might be related to the fact that universities in those regions typically offer a food engineering degree, and chemical engineers are unlikely to work in the food industry. Conversely, in European and North American countries, chemical engineers are the professionals hired to work as food process engineers since the food science degree lacks exposure to core engineering disciplines. Bucknell[2] and Rowan[3] Universities are two examples that offer an elective course devoted only to food engineering/science to chemical engineering students in the United States. This observation served as motivation to the author to implement a new elective food engineering course in the Chemical Engineering Department at UC Davis. The course is a modified version of a course previously offered at Rose-Hulman Institute of Technology;[4] however, some of the assessments were modified with the objective of addressing topics such as diversity, equity, and inclusion in the course.

The novelty of this work was to expose students to Native American culture and traditional foods native to California, and to challenge students to propose a shelf-stable product based on indigenous food while considering a variety of constraints. The selection of Native American foods compared to other cultures deserves an explanation. Firstly, the instructor wanted to educate students on the foods native to the place where they live. While different kind of foods are currently grown in California, only a few were originally grown from this land before colonization began. Secondly, anecdotally, chemical engineering students are rarely exposed to indigenous history and culture in their curriculum. Therefore, some of the assignment's objectives were to increase students' awareness of this population and the challenges these populations still face due to colonization. Moreover, it was also of interest to discuss some practices students could follow as individuals to support Native Americans in their profession and in their communities. To accomplish this task, the Ohlone people were selected since they are in the Northern California Coast, which is near UC Davis, and they already perform educational programs across the nation.

The assignment presented here consisted of assessing students' ability to apply food preservation strategies. A problem-based approach was used, inspired by the applied food science course offered by Bucknell University.[2] The instructor believed it was important to develop an assignment that would align with some of the ABET EAC Student Outcomes.[5] In addition, the instructor wanted to promote critical thinking, problem-solving, teamwork, entrepreneurship, and consideration of regulatory and cultural considerations. Finally, although elective classes are not used to assess ABET EAC Students Outcomes, such outcomes are the standard to evaluate the effectiveness of the preparedness of students to engineering practice. Moreover, this assignment can be used as a baseline for others interested in developing similar assessments in core engineering classes as described in the 'instructors' reflections" section.

The use of culturally relevant pedagogy has shown several benefits, especially to underrepresented minority students such as Black or African American, American Indian or Alaska Native, Hispanic or Latinx, Native Hawaiian or

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Pacific Islander.[6-7] This is because this pedagogy (1) allows students to recognize and honor their own culture while acquiring knowledge to other cultures, (2) encourages students to think critically, and (3) increases students' sense of belongingness, self-confidence, empathy, and interpersonal skills.[6,7] The core ideas of culturally relevant pedagogy were used to develop some of the course and assignment learning outcomes (Table 1). Moreover, due to the importance of culturally pedagogy, additional objectives of the work were to collect demographic information of students interested in the course and identify students' perception of associated ABET EAC Student Outcomes mapped with the assignment.

RESEARCH DESIGN

Research Questions

The research questions were as follows:

1. What is the demographic information of students interested in the new elective food processing class?
2. Are students' perception of associated ABET EAC Student Outcomes aligned with the assignment?
3. Did the assignment increase students' awareness of Native American culture?
4. Was Native American culture considered in the students' proposed solutions?

Demographic Information

This study was considered exempt by the Institutional Research Board at UC Davis and demographic information of students (gender, ethnicity, if first generation, if low income) was collected with their consent.

Assignment Design

To answer research questions (2) and (3), the assignment was designed by following the transparent assignment approach [8] which includes the readings of Purpose, Task, Criteria for Evaluation, specific instructions to complete the final deliverable (written report), and the rubric to assess learning outcomes. Students then attended a talk delivered by Native American chefs Vincent Medina and Louis Trevino on Ohlone culture and traditional food. The chefs were contacted by using their business website at https://www.makamham.com/contact. Due to the sensitive nature of representing Native American culture, both chefs were consulted before releasing the assignment to students. In order to increase students' exposure to Ohlone culture, the assignment statement included the name of the traditional

TABLE 1
Course Learning Objectives

Course Outcomes: Upon successfully finishing this course, the students are expected to acquire or improve upon the ability to…
a. Apply principles of chemistry, physics, and engineering in the context of food processing and new food product development
b. Recognize key aspects of food science, texture, components, preservation, and flavor
c. Describe main food processes and their impact on food components and microorganisms
d. Describe key aspects of food product development (formulation, scale-up, sensory attributes, ethics, etc)
e. Determine hazards associated with food processes as well as strategies for reducing food contamination
f. Communicate food design processes effectively
g. Work effectively in a team
h. Develop and exercise interpersonal skills, empathy, and sense of belonginess by acquiring knowledge of other cultures
Assignment Outcomes: The purpose of this assignment is to help students practicing the following skills that are essential to their success in food industry and professional life beyond school:
a. Applying basic food processing/preservation knowledge to problem-solving in a new context that is similar to others you've studied in class
b. Evaluating and selecting best solutions based on FDA regulations
c. Creating a new product
d. Working effectively on a team
e. Communicating food product design effectively
f. Considering ethical and cultural responsibilities in food product development

foods presented by the chefs in their native language. Then, students were asked to work in groups of three to propose a new shelf-stable product based on Ohlone culture while following the regulations dictated by the Food and Drugs Administration (FDA), estimate shelf-stability through calculation of water activity using Raoult's Law, and address cultural appropriation. After the report submission, students completed an individual reflection assignment that had the objectives of synthesizing what they learned from the assignment, defining challenges and criteria to overcome the challenges faced by the team, and discussing the connection between the assignment and the concepts covered in class and other engineering disciplines. For assignment statements, contact the author at ghprado@ucdavis.edu.

Students Perception of Associated ABET EAC Student Outcomes

Learning outcomes specific to this assignment are described in the Table 1, and their associated ABET EAC Student Outcomes are listed in Table 2. Along with the report submission, students answered a voluntary survey to evaluate their perception of associated ABET EAC Student Outcomess. The survey consisted of questions indicating the likelihood of their agreement or disagreement with associated ABET EAC Student Outcomes description (Table 2) using a 5-point Likert-type scale from Strongly Disagree to Strongly Agree. Open-ended questions were also included to provide feedback to the instructor and suggestions for further improvement (Table 3). The voluntary nature of the survey resulted in a small sample size (n = 13), and it was difficult to obtain statistically significant results; however, the results were used to identify trends, areas of improvement, and needed modifications.

TABLE 2
ABET EAC Student Outcomes Associated With The Assignment

ABET Outcome[5]	Description
1	An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2	An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
5	An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
7	An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

TABLE 3
Open-ended Questions to Improve Assignment Design

Question	Description
1	What do you feel was the most useful aspect of this assignment?
2	What about this assignment do you feel needs the most improvement?
3	What other feedback do you have regarding this assignment?

COURSE FORMAT

The course was an upper elective class, and it was offered to senior and graduate students. If seats were available after seniors and graduate students enrolled, enrollment was also available to juniors. There were a total of 25 students (12 seniors and 13 juniors) from chemical and biochemical engineering majors. The prerequisite class was Chemical Engineering Laboratory II, since students who had completed this course were already exposed to the engineering concepts required for the food engineering class. Classes were offered twice a week and lasted 100 minutes per week. Since it was the first offering, there were a total of four labs, and future labs are currently under development.

Demographic Information

The number of women and men enrolled in the class was 28% and 72%, respectively. Female enrollment was slightly lower compared to overall department enrollment (42% - Table 4). This result was unexpected, since a previous study indicated that the food and beverage industry is the second career choice of female chemical engineering students [1] and, therefore, it was expected that the course would attract more female students. Regarding ethnicity data, most students declared themselves as White (36%), followed by Hispanic (32%), Asian (28%), and two or more races (4%). The total number of Asian students enrolled in chemical engineering is greater than Hispanic. This result is opposite than the students interested in the course (Table 4). There were no students who declared themselves as Black or Native-American. Demographic information indicates that 16% of the students were first generation while 4% were low income. Moreover, 20% of students were both first generation and low income. This reflects overall department enrollment (Table 4).

TABLE 4
Demographic Information of Chemical/Biochemical Engineering Students Enrolled in the New Elective Food Processing Course (Spring 2022/UC Davis) and Overall Enrollment

Description	Food Engineering course enrollment (Amount, %)	Chemical Engineering Department overall enrollment (Amount, %)
Gender		
Women	28	42
Ethnicity[a]		
Asian	28	45
Black	0	5
White	36	43
Latinx/Hispanic	32	26
American Indian	0	2
Pacific islander	0	1
Two or more races	4	b
Economic Status/Generation		
Low income only	4	5
First generation only	16	14
Low income and first generation	20	19

a. Department enrollment adds to over 100 % since students can select more than one race
b. Data not available from the Office of the Registrar

RESULTS

Native American Chefs' Lecture

The lecture was delivered by Vincent Medina and Louis Trevino from Café Ohlone. Students were required to read the assignment before attending the lecture to develop questions for the chefs and were allowed two weeks to deliver their final report. The talk began with a history of Ohlone culture and food. The chefs emphasized that during colonization of the East Bay Area in California, traditional practices, religion, language, and food were banned. They said the tribe had to hide in remote areas to keep their culture alive when the first California governor called for their genocide in the 1850s. As pointed out by the chefs, Café Ohlone, located at UC Berkeley, has served as an instrument to reenter society and educate people on Ohlone culture. More importantly, they encouraged students to talk about Ohlone people. They emphasized that they are a living community located in the Bay Area that have victoriously kept their culture and people alive despite external efforts to exterminate them.

The chefs also performed a cooking demonstration, where they prepared a chia seed porridge [*pattih*] that was cooked with traditional and local ingredients (Figure 1a). For example, the porridge was prepared with nut milk, and it was sweetened with candy cap mushroom that possesses a caramel/vanilla/maple flavor and grows only in the West Coast of the United States. The chefs also served their signature Ohlone brownies [*rawwni*] prepared with black walnuts and chia seed flour and sprinkled with hand-gathered San Francisco sea salt (Figure 1b). A rosehip tea [*mamakwa tawwa sii*] was also served to accompany the desserts (Figure 1c).

Students' Solutions

For the assignment, students were asked to propose a shelf-stable product inspired by any of the three foods presented by the chefs (chia porridge, brownies, or rosehip tea). The proposal of a new product was imposed because although the chia porridge recipe was shared by the chefs, the other two recipes were not since they are part of their intellectual property. In order to evaluate the effectiveness of their solution, students were also asked to benchmark the product and perform a cost analysis based on ingredients only. This was because the junior students enrolled had not yet taken the "Introduction to Design" course, where economic analysis is taught. An explanation of the main reactions and the function of each ingredient were also required to be described in the report, since they define preservation strategies to be selected.

All students' Ohlone-inspired food products were carefully designed to honor Ohlone culture, which aligns with course learning outcome (h) (Table 1). The chefs taught about the importance of using local and natural ingredients,

(a) (b) (c)

Figure 1. (a) *Chia porridge [pattih] with blackberry coulis [enesmin sii],* (b) *Ohlone signature brownies [rawwni],* (c) *Students trying rosehip tea [mamakwa tawwa sii]. (Pictures: Nikita Mistry/UC Davis)*

so students searched for natural and local substitutes that had a lower cost but would result in a product with similar texture and flavor to the food presented by the chefs. Selected examples of students' proposed products are presented in Table 5. For example, one of the proposed solutions was to carbonate the rosehip tea and use a natural sweetener (agave syrup). The preservation strategy used was addition of Vitamin C, which is a natural antioxidant. Another group chose to prepare brownies and replace wheat flour with acorn flour and add black walnuts native to California. The most typical method to preserve commercial brownies is the addition of sodium benzoate to prevent the growth of bacteria and certain molds. By considering the teachings of the chefs to use more natural ingredients, the group replaced sodium benzoate with clove and cinnamon essential oils, which are approved by FDA for consumption and inhibit the growth of bacteria and mold. However, this substituion would result in the shelf-life decreasing from two years to two months. To overcome this challenge, students proposed to market their product as artisan brownies and sell them in packs of 12, which can be easily consumed within the two month shelf life. The packing would be 2x3 layers of brownies separated by a thin piece of wax paper. The wax paper also acts as preservative since it absorbs moisture and prevent the growth of bacteria and mold in the brownies. Another group chose to develop an instant chia porridge, and the benchmarked product was Quaker Oats instant oatmeal. Since the candy cap mushroom grows in the wild and is not readily available, the group replaced this sweetener with vanilla sugar to decrease the cost. In addition, black walnuts were replaced by cheaper English walnuts. Although they have a milder flavor compared to black walnuts, the main purpose was to add the same texture to the commercial product. Since the walnuts and the chia seeds have a high content of oil-containing polyunsaturated fatty acids, the preservation strategy proposed was to pack it under vacuum to decrease the oxidation reaction rate. In addition, the group generated the nutritional label of their product by using the website www.recipal.com (Figure 2), which enabled them to estimate the water activity of their final product (0.86) using Raoult's law.[9] According to FDA regulations, a product is shelf-stable if water activity is below 0.85 since this prevents microbial growth.[10]

Chia Seed Porridge Without Nut Milk

Nutrition Facts

4 servings per container
Serving size (64g)

Calories per serving **250**

Amount/serving	% Daily Value*	Amount/serving	% Daily Value*
Total Fat 12g	**15%**	**Total Carbohydrate** 32g	**12%**
Saturated Fat 1g	**5%**	Dietary Fiber 9g	**32%**
Trans Fat 0g		Total Sugars 19g	
Cholesterol 0mg	**0%**	Includes 11g Added Sugars	**22%**
Sodium 250mg	**11%**	**Protein** 5g	

Vitamin D 0mcg 0% • Calcium 160mg 10% • Iron 2.1mg 10% • Potassium 140mg 4%

* The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Ingredients: Chia Seeds, Elderberry Jelly (Elderberries, Sugar, Cane Sugar, Pectin, Lemon Juice, Citric Acid), Walnuts, Vanilla Sugar (Sugar Cane, Vanilla Bean, Vanilla Bean Extract), Kosher Salt

Contains: Walnut

Figure 2. *Nutritional label of instant chia porridge generated by students.*

The assignment also requested that students consider cultural factors and propose solutions to deal with cultural appropriation should one wish to commercialize a food product based on Ohlone culture. Students concluded that their product would be considered cultural appropriation because they (1) would be commercializing a cultural product for profit that would not benefit Ohlone people, (2) they did not receive approval from the Ohlone tribe, and (3) no one on the team is part of the Ohlone tribe. Based on their conclusion, students proposed solutions that were above expectations of the instructor. Some examples included onboarding an Ohlone person on the formulation process to have guidance and instruction to ensure that the product is made as authentically and as respectfully as possible; increasing profit margin to ensure that a portion of the sales revenue is donated to the Ohlone tribe foundation; and marketing the product as Ohlone product, where the package would contain historical and cultural importance of the product or include a QR code to a website where people may learn more about Ohlone culture and history.

TABLE 5
Selected Students' Examples of Shelf-Stable Food Products Inspired by Ohlone Traditional Food

Chosen Ohlone traditional food	Inspired food product	Benchmark	Ingredient cost (Benchmark)	Ingredient cost (Ohlone-inspired food product)	Preservation strategies
Rosehip tea	Carbonated rose hip agave tea	Cold tea and carbonated soft drinks	not reported	$ 0.840/can	Vitamin C (antioxidant)
Brownie	Brownie made with ingredients native to California (acorn flour and California black walnuts)	Commercial brownies made with wheat flour	not reported	$ 1.67/box (12 brownies/box)	Use of clove and cinnamon essential oils Separate individual brownies in the box with wax paper to absorb moisture
Chia porridge	Instant chia porridge	Quaker Oats instant oatmeal	$0.39/per serving	$0.92/per serving	Packed under vacuum to avoid oxidation of unsaturated fats present in walnuts and chia seeds

Students' Reflections

For the individual reflection assignment, students had to answer (1) what topics of the class and other engineering courses helped them to complete the project, (2) what was the most difficult challenge, and how the group overcame the challenge, (3) what was the main criteria used by the team to make decisions, and (4) what they learned from the assignment.

Students selected food preservation as the main valuable concept learned from the food course to complete the project – more specifically, water activity and food preservatives. On the other hand, economic analysis followed by heat and mass transfer, thermodynamics, and organic chemistry were mentioned as the most important concepts learned from previous engineering classes.

The most challenging technical issue faced by students was to identify ingredients that are important to Ohlone culture, that are not heavily processed, that have lower cost than the benchmarked product, that are local to the Bay Area, and that would give the final product a similar texture and flavor of the original dishes presented by the chefs while following FDA regulations. A non-technical challenge faced by one of the groups was team communication. Based on a student's comment (shown below), the assignment was helpful for students to develop communication and conflict resolution skills (course learning outcome (g) – Table 1):

> *"The most difficult challenges were an imbalance in workload distribution, an imbalance in effort, and unconscious disagreement on our expectations. So, to remedy this, I communicated my feelings and we have decided to have one or two meetings to discuss our expectations and our capacity for contribution. I think just being on the same page about our expectations of the quality will go a long way."*

It was unanimous that the main criteria to make decisions was respect and honor of the Ohlone community while following the constraints imposed by the assignment. This aligns with course learning outcome (h), described in the Table 1, which was inspired by one of the culturally pedagogy's goals, which is to develop empathy to other cultures.

Regarding the learnings from the project, students mentioned appreciation of food product development and its processing since multiple factors must be considered, such as sensory attributes and product safety, that are not required for other chemical processes. Learning about Ohlone culture and history, and taking cultural factors into consideration when designing engineering solutions (assignment learning outcome (f) – Table 1) were also unanimously mentioned by students, as illustrated by some of the students' comments extracted from the reflection assignment:

> *"In this assignment, I learned about the necessary steps required when coming up with a new food product. It is important to always consider the culture after which a traditional product is inspired from. If an alteration, or addition, to the recipe is required, then making sure that the recipe still represents the culture is important. Plenty of research is required in order to create a product that is flavorful and safe to consume.*

Reading FDA documents and regulations regarding aseptic processing was very insightful. I saw terms and expressions that I learned in class being applied to the real world, which made the whole research process much more interesting and easier."

"This case study allowed us to incorporate material from our Food Engineering course while maintaining an intersectional lens that is important as we move beyond the academic scene and into industry where the biggest focus is monetary gain. As a chemical engineer, I want to change the industry standard and promote diversity, inclusion, and respect of all people. The Ohlone Chefs gave us wisdom of their culture to understand the community and honor behind their food, which is often lost in a commercialized market. This is a major step in my academic career to shape my understanding beyond industry standards and into creating the new norm."

ABET EAC Student Outcomes

The average and standard deviation responses of each statement (ABET EAC Student Outcomes – Table 1) are shown in Figure 3. Thirteen of the twenty-five students enrolled in the course answered the survey. As a cohort, all students felt that the ABET EAC Student Outcomes mapped with the assignment were achieved (Figure 3).

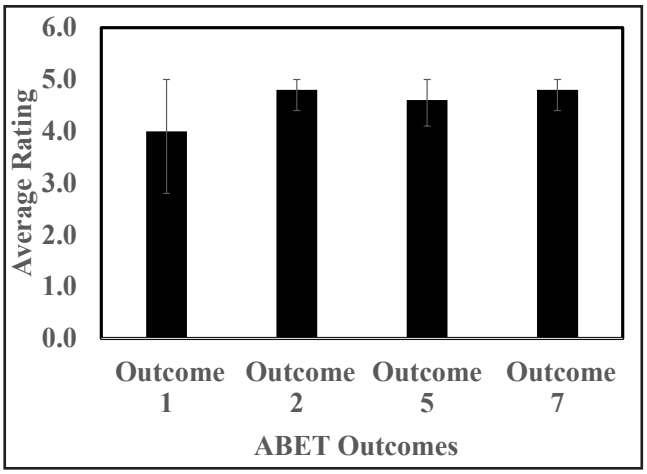

Figure 3. *Students' perception of ABET EAC Student Outcomes (Table 2) associated with the assignment. Sample size is 13 and error bars represent the standard deviation.*

DISCUSSION

The assignment was well received by students as shown by responses to the open-ended questions in the anonymous voluntary survey. It revealed that the most useful aspects of the assignment were the application of the learned concepts in the real world and working on a team, as pointed out by one of the students (*"Having to do research with a group is a great skill to have. This assignment has helped me develop and polish these skills, which I do not really experience that in other classes")*. Most of the students felt that the assignment was good, and the main criticisms were regarding providing more detail about the food presented by the chefs and a list of popular websites for professionals working in the food industry. When asked about what other feedback they had regarding the assignment, most of the students mentioned the creativity aspect of the assignment and that it was well designed with sufficient guidance.

Students felt that the ABET EAC Student Outcomes associated with the assignment were met (Figure 3). While not statistically significant, written responses from underrepresented students suggest that the assignment was beneficial to those students.

One important outcome from this assignment was its relevance while assessing other general course learning objectives (Table 1), which consisted of a capstone project and food additives research described elsewhere.[4] In the capstone project, students were asked to develop a food product not commonly available at grocery stores. While food preservation strategies were also required in the capstone project, other criteria were included such as a process flow diagram, scale-up, and hazard and identification analysis of critical control points. Ethics and cultural considerations were not required in the capstone project. However, students considered the teachings of the chefs to select natural ingredients and industrial processes that would honor traditional recipes. They also considered their own cultural aspects to develop their food products.

For example, a team consisting of only Latino students developed a *tres leches* donut. Another example consisted of a team composed of two Filipinos and one white American whose capstone food product was *halo-halo*, a Filipino desert. The American student decided to surprise the other teammates by trying the *halo-halo* and educating himself on the cultural aspects of the project. This was appreciated by the Filipino students as indicated in the peer-evaluation assignment (*"He's also very respectful of other's cultures, he actually tried halo-halo for the first time!"*). These examples illustrate the importance of using culturally relevant pedagogy, i.e., students were able to recognize and honor their own culture while acquiring knowledge to other cultures and increasing their sense of belonginess, self-confidence, empathy, and interpersonal skills (course learning outcome (h) – Table 1).

In addition to the described observations, potential leads for future investigation were identified to improve the initial assignment design:

a. Pairing theoretical solutions with hands-on activities would increase students' learning. After formulation

and water activity estimation, students would cook both the benchmarked and their proposed products to perform sensory and analytical analyses, including water activity measurement.

b. Students' solutions could be presented to the chefs in order to obtain their feedback on creativity, product quality, and cultural appropriation.

c. Native American chefs from other tribes could be invited every year to increase students' awareness of different Indigenous communities in California.

d. UC Davis is an Emerging Hispanic Serving Institution with a high number of Hispanic students, where 32 % of the students enrolled in the course were Hispanic followed by 28% of Asian students (section 4). Therefore, the presented assignment can be modified to invite chefs from other ethnicities to expose students to different cultures and promote inclusive teaching.

Instructor's Reflections

The outcome of this assignment corroborates to the importance of using culturally relevant pedagogy to increase students' empathy and respect to other cultures while designing a solution to a proposed problem. This raises the question how a similar assignment could be developed to other chemical engineering classes. The author suggests: (1) to use local Native American tribes or cultures that represent the student population at the department; (2) the instructor should educate themselves on the culture to be discussed, either by performing a literature review or contacting local individuals that represent that culture, (3) from the knowledge acquired on products and processes used by the researched culture, the instructor should reflect on how this information can be linked to chemical engineering classes. For example, ancient cultures utilized several plants originated from their land to cure diseases. After attending a talk from local individuals representing the chosen culture, an assignment could be designed to apply mass transfer fundamentals to design an extraction process to obtain the active component from the plant to produce a pharmaceutical product. Finally, it is also recommended to consult with representatives from the culture regarding the nature of the assignment and its objectives to avoid misinformation and to respectfully honor their culture.

CONCLUSIONS

The manuscript describes an assignment to assess students' learning on food preservation strategies based on Native American food presented by Native American chefs. Results have shown that the assignment was aligned with students' perceptions of ABET's outcomes while considering FDA regulations and promoting diversity in a chemical engineering elective class. Students' solutions prioritized the teachings of the chefs in respecting natural ingredients and handling cultural appropriation. Some recommendations were provided to improve the initial assignment design and students' learning, such as pairing theoretical solutions with hands-on projects and inviting chefs from different ethnicities and culture in future years. Recommendations and instructions are also provided to create similar assignments for other courses.

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