Kitchen Chemistry: The Utility of Food and Biochemistry- Basic Laboratory Activities (FB-BLAc) for Instruction

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Abstract

The shift from face-to-face to online delivery of instruction brought by the COVID-19 pandemic posed a challenge on how science skills could be honed without the hands-on laboratory experience for chemistry teaching and learning. The science, technology, engineering, and mathematics (STEM) academic programs such as BS in Food Technology taking Biochemistry and Food Chemistry have been put to a greater test due to the concern over doing face-to-face laboratory and practical activities. The feasibility and acceptability of kitchen chemistry for remote laboratory instruction motivated the development and enhancement of the Food and Biochemistry-Basic Laboratory Activities (FB-BLAc). The study aims to assess the acceptability of FB-BLAc resulting from the evaluation of students. A total of 66 students 3 rd year students from the BS Food Technology program performed and assessed the acceptability of FB-BLAc in terms of its utility for instruction. Based on a mixed-method design employed in this study, the student respondents generally agree with the features of FB-BLAc. Thematic analysis was made on the responses to the open-ended questions that relate to the importance, advantages, and challenges encountered while doing FB-BLAc. The results suggest higher acceptability of FB-BLAc grounded on the cited importance and advantages, especially in promoting learning and developing science skills by providing remote laboratory experiences. In conclusion, the FB-BLAc is a better way of aiding instruction for food and biochemistry through the utilization of easily accessible materials. Through the experiences gained from the implementation of FB-BLAc, more specific instructions must be provided to students but will not compromise the open-ended aspect of doing at-home laboratory activities. A better design for the implementation of FB-BLAc can be developed which will cover practicability, a wider range of topics, and alternatives for different materials.

Keywords: kitchen chemistry, food chemistry, biochemistry, laboratory activities, instruction

1 Introduction

The suspension of face-to-face instructional activity as a result of the COVID-19 pandemic has placed faculty of science more particularly in situations where they have to find ways of delivering instruction that will provide the necessary experiences among students in learning most especially in the field of chemistry. Though the immediate shift to remote learning has prompted the development of ideas and approaches that were tested and evaluated, these shifts and changes have effects on chemistry teaching [1]. Regardless of the digitalization of teaching, there still stands the requirement of providing apt experiences among students in achieving chemistry education. There is a need to go to the reverse process of offline teaching where the acquisition of practical skills like in organic chemistry is a requisite [2]. The adaptation of online teaching method in chemistry via synchronous and asynchronous modes have also been studied and tried. The students in the study carried out by [3], despite their preference for face-to-face teaching and learning have also found advantages on these modes such as the saving of time and flexibility in schedule.

Experiential-based learning is a budding and rich area for studying development, especially in the stage leading to adulthood. Using the concept of experiential education or experiential learning, educators facilitate learning by including the method into the course and inspiring reflection, and providing a collaborative learning environment [4]. Thus, in teaching science especially in chemistry, laboratories are significant environments that provide ample experiences and strengthen knowledge gained from lectures and learning materials. The hands-on experience that the laboratory provides is essential for every chemistry student's learning.

Regardless, through technology virtual labs are made possible and have been received positively by students [5]. These can help improve learning and performance particularly when there is a blend of visual, auditory, and kinesthetic modes of learning within the sphere of the virtual lab [6]. However, hands-on laboratory experience is still undoubtedly recognized to encourage and hone science skills. Students who engage in well-made laboratory experiences develop and enhance their problem-solving and critical-thinking skills. Though both the virtual labs and physical labs can promote the achievement of different learning objectives, the latter can promote inquiry activities like planning, experimenting, and experiment enhancements [7]. That is, when a physical lab is utilized, the student's level of process skill mastery in experiments can be improved [8]. Likewise, experiences in the laboratory may help students perform better with the concurring belief of their reinforced and improved understanding of concepts presented in lectures and textbooks [9].

Undoubtedly the COVID-19 pandemic posed a greater challenge to chemistry education as the question of its role and efficacy has been raised. With the remote learning, the outcomes of the modifications made on laboratory education were placed in speculation. The lack of hands-on laboratory experience was considered detrimental to particular types of student learning and engagement [10]. More particularly for science, technology, engineering, and mathematics (STEM) courses or programs, these have been put to the greater test due to the concern over doing face-to-face laboratories and practical activities. Admittedly, hands-on experience in particular subject disciplines cannot be achieved through online laboratory practices. This poses a challenge to universities and educational institutions on how new methods could still maintain the quality of education utilizing the online laboratory activities [11].

The teaching of general chemistry laboratory course, for example, was thought to be challenging to teach since students have varying chemistry backgrounds and levels of understanding. This is further hurdled with the adjustment from in-person to remote teaching and learning. However, this challenge led to the development of approaches through the help of students themselves to lighten the adjustment and promote pedagogy that is tailored for remote learning [12]. The use of available kits for remote laboratory instruction has been an alternative for remote laboratory activities. Although for some laboratory exercises no kits are available, an alternative to device homemade kit can be called for [13]. With this, it is evident that the shift to remote laboratory instruction prompted and encouraged innovativeness in developing techniques in utilizing available alternative materials to suit the laboratory course requisites. Additionally, the comparisons between online laboratory experience and traditional setting indicate that students in the online science courses with laboratory could fare well based on the skills gained and improved understanding of concepts [9].

In acknowledgment of the aim of promoting learning, engagement, and performance, hands-on laboratory instruction must necessarily be in the classroom. However, an alternative can be made by sending home students with the requisite supplies [10]. By providing materials, students can be equipped in performing laboratory activities in a remote setting. Conversely, if not viable, an alternative is to source out materials that can readily be available or are commonly found especially in the kitchen. Schultz et al. [14] developed kitchen chemistry activities with worksheets that link observations to theories or concepts taught in class. Mainly their objectives are to develop students' observational skills, acknowledge the significance of quantification and its expression, and provide safe hands-on activities in their households. Likewise, designing experiments that will only employ the use of safe household materials with no special equipment proved to promote positive experience and better understanding of concepts among students [15].

The feasibility and acceptability of kitchen chemistry for remote laboratory instruction motivated the development and enhancement of the Food and Biochemistry-Basic Laboratory Activities (FB-BLAc) intended for students taking STEM programs, especially the Food Technology program. Here, addressing the concerns over providing laboratory experiences aligned with the course content for Food and Biochemistry instruction was the primary objective. The developed FB-BLAc was also designed to assist students in refining their scientific skills in the safe confines of their homes.

Purpose of the Study

The study is designed to achieve the following objectives: (1) to determine the students' acceptability of FB-BLAc after its implementation; and (2) to distinguish FB- BLAc's importance, advantages and challenges, and recommendations to provide inputs for its improvement.

2 Methods

The Design and Development of FB-BLAc

The basis for the design of FB-BLAc was the course content for Food Chemistry 1 and Biochemistry of the Bachelor of Science in Food Technology which mainly focus on the major food component of food: water, carbohydrates, lipids, and proteins [16]. The developed FB-BLAc can be flexible for other STEM programs with courses covering the same or similar course content. Common kitchen materials and cooking ingredients as well as materials that are safe and can readily be availed were considered in the development of each activity. For example, the pH paper strips which can provide approximate pH values can easily be availed online and is cheaper as compared to litmus papers and pH meter.

Each laboratory activity worksheet has the following components: Objectives, Materials, Procedure, Results and Discussion, and Conclusion. The students have to compose their objectives based on the topic and what can be deduced from the procedure. The materials and procedures have to be discussed in the class to provide guidance. The proper handling and possible substitution of materials also have to be taken into account.

For the results and discussion, students have to include documentation of the activity. Results are usually to be presented in tables with the images and description of results followed by guide questions. Short video documentation may also be included in the report. Moreover, students have to write their conclusion at every end of the laboratory activity report. Lastly, the post-lab discussion has to be carried out through online meetings.

For each major topic (see Table 1), specific topics were selected and limited for certain materials and types of observations that can be gathered. The results of the activities can provide tangible input to the discussion of each topic while assisting students to hone their science skills despite performing laboratory activities in a remote setting. Furthermore, FB-BLAc can flexibly be used by incorporating the laboratory activity results in the discussion of other related lessons.

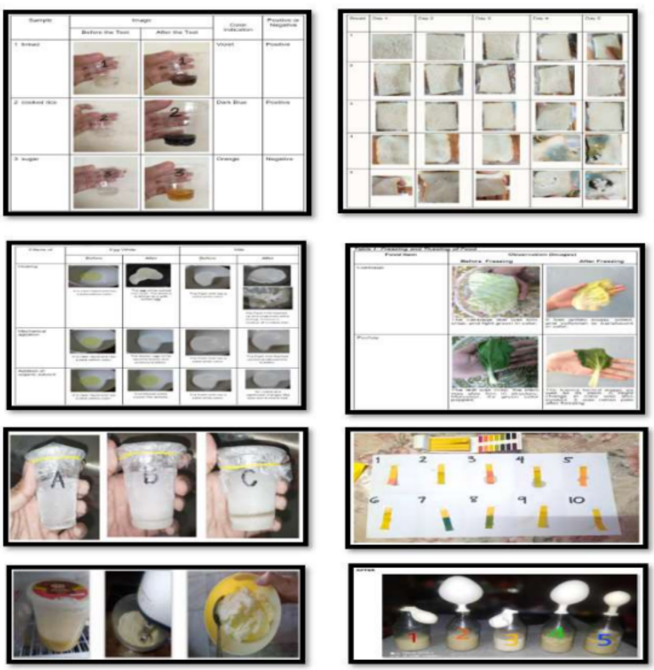
Major Topic	Activity Title	Specific Topic	Materials
Water	Colligative Properties	Effects of Amount of Solutes on Rates of Boiling and Freezing	distilled water, table salt, table sugar, pan, and stove
	pH and pOH	Determination of pH and pOH of different household chemicals	vinegar, detergent solution, calamansi juice, distilled water, softdrink, shampoo, dissolved baking soda, antacid, ascorbic acid, coffee, bottle caps or plastic cups
	Water in Food 1	Effects of Frozen Water on Different Food Materials	cabbage and pechay leaves, carrot, onion, fish meat, banana, gelatin, freezer
	Water in Food 2	Water Activity and Moisture Content in Food	slices of bread, water, silica gel, microwaveable or zip lock containers
Carbohydrates	Iodine Test for Starch	Presence of Starch in Different Food Samples	bread, rice, table sugar, banana, potato, soda cracker, milk powder, egg white, povidone-iodine, plastic cups
	Fermentation	Yeast Fermentation Enzymatic Action	starch, table sugar, fresh milk, ripe banana, and/or ripe mango, yeast, clear bottles, balloons
Lipids	Mayonnaise	Role of Emulsifiers in Food Processing	egg, oil, vinegar/citrus fruit
Proteins	Denaturation of Proteins	Different Agents for Protein Denaturation	egg albumin, fresh milk, ethyl alcohol, vinegar/citrus fruit, pan, stove

Participants and Implementation of FB-BLAc

The participants were 66 second-level undergraduate BS Food Technology students of the College of Science of Bulacan State University enrolled in the second semester of the school year 2020-2021. They were all enrolled in Food Chemistry 1 and Biochemistry. Before the performance of each activity, students were oriented to observe the safety guidelines as if they are in an actual laboratory room. During the course of implementing the FB-BLAc, students were accordingly guided through discussions of procedures in the online meetings. For each activity pre- and post-lab discussions were carried out. Differences in the individual outcomes were discussed to provide the reason and identify the probable cause for not meeting the desired results.

Figure 1

Screenshots from FB-BLAc reports



Research Instrument for Acceptability of FB-BLAc

After the implementation of FB-BLAc, the student-respondents made an evaluation and provided feedback on its acceptability for utilization for instruction using a developed self-made survey instrument [17]. This was carried out using an online survey form with a list of 17 statements answerable using a Likert scale ranging from 1-5 where 5 is considered as highly agree and 1 as highly disagree and three open-ended questions that inquired about the importance, advantages and challenges, and recommendations for enhancement of FB-BLAc. The items were evaluated and validated by colleagues in the field. The open-ended questions were included to identify the importance, challenges, and recommendations for the enhancement of FB-BLAc. Answers for the open-ended questions were coded and thematized. Initial or open coding and focused coding were employed for the first and second cycle coding [18]. Results are presented in Tables 3-5.

3 Results and Discussion

The students' agreement on the acceptability for utilization of the FB-BLAc was determined using a 5-point Likert scale with 5 as highly agree and 1 as highly disagree. The results (Table 2) indicated an average weighted mean of 4.46 which shows that in the survey, the students agree on the statements relating to the different features of FB-BLAc. The item on FB-BLAc's relevance to the topic being covered garnered the highest mean, while the item relating to the sourcing of materials obtained the lowest mean. Additionally, the 0.58 average standard deviation indicates a closeness to the mean of the data set. This provides a further understanding that the majority of the student-respondents have similar responses on their agreement to the acceptability of the FB-BLAc.

Table 2
Students' agreement on the acceptability of FB-BLAc based on its features and their utilization

Item	Statement	Mean	SD
1	Each title represents what the activity is about.	4.59	0.55
2	Each activity has a procedure that is clear and easy to follow.	4.44	0.61
3	The data to be collected and presented match the purpose of each activity.	4.54	0.52
4	Each activity is relevant to the topic being covered.	4.71	0.43
5	Each activity helps understand the topic at hand.	4.59	0.5
6	Each activity can be performed remotely.	4.35	0.71
7	Materials for each activity can readily be sourced.	4.25	0.76
8	Each activity can be performed at a given time frame.	4.32	0.77
9	Results of each activity match concepts applicable in real-life situations	4.32	0.65
10	Results of each activity can be used for other related concepts	4.44	0.54
11	Doing FB-BLAc independently provided me opportunities in enhancing my learning in Food and Biochemistry.	4.64	0.44
12	FB-BLAc provided me with more understanding of the topics covered.	4.52	0.56
13	FB-BLAc helped me enhance my skills in developing objectives, presenting/processing data and results, and formulating a conclusion.	4.54	0.55
14	FB-BLAc helped me in enhancing my planning and decision-making abilities.	4.39	0.54
15	The learning experiences I gained in performing FB-BLAc strengthened my knowledge of the topics involved.	4.34	0.58
16	The experiences I gained from FB-BLAc helped me become more confident in doing independent future activities and projects.	4.49	0.49
17	Concepts covered in FB-BLAc provided me opportunities to reflect on their applicability in real-life situations.	4.34	0.58
	Ave	4.46	0.58

[a]*Note. N=66*

The following tables provide summaries of the students' responses to the open-ended questions. Thematic analysis was employed that resulted in the main themes. To establish the trustworthiness of the analysis the researchers went through the phases of thematic analysis, namely: familiarization with data, generation of initial codes and themes, search and review of themes, defining themes and developing a report of analysis [19].

Based on the responses regarding the importance of FB-BLAc, most of the students revealed that it has significance in enhancing skills and learning. The importance was generally themed as (1) easy, convenient and practical, (2) enhancing skills and learning, and (3) providing learning experiences. Some students have expressed their appreciation of doing activities at home using readily available kitchen materials. Also, they have an understanding of how relevant the activities are in promoting their understanding of the theories being covered and acknowledge that the activities despite the remote mode of learning could still help them develop the relevant skills for their future career.

Table 3

Summary of thematic analysis for students' acknowledgement of the importance of FB-BLAc

Importance	Frequency	Examples
Easy, Convenient, and Practical	15	"Having actual laboratory is easier and more convenient for me." (R-1) "It is important because I have learned many things and applied them to my laboratory experiments with accessible materials that can be found and done at home." (R-6)
Enhancing Skills and Learning	32	"It is very important because I can apply what I have learned in the discussion and I can practice it physically and understand more. "(R-2) "During these unprecedented times, FB-BLAc gave practical courses (where) students have the chance to gain slight expertise regarding the concepts revolving around their program. Students, like me, should not take these for granted for alternatives as such, while being far from the professional set-up, is the most that we can do now - take and squeeze out as much of the necessary information from these." (R-4)
Providing Learning Experiences	10	"It's very important because it helped us to gain more experience and (learn) the applicability of the laboratory activities." (R-8) "Dahil makakatulong ito sa aking trabaho in the future (Because it will help in my future job/career)" (R-14)

Note: Out of 66 student-respondents 45 responded to the question: How important to you is the performance of actual laboratory activities like FB-BLAc? Why? On the advantages and challenges of doing FB-BLAc, 49 of 66 students have expressed the benefits of the activities. The advantage of doing FB-BLAc, generally, it is practical and can improve self-learning. The students have cited enhancement of learning or understanding the lessons better, learning and doing work individually, building self-confidence, and activities are practical to do. On the other hand, some issues on resources served as the major challenge. 33 student-respondents have cited their issues or concerns which include the capacity to avail and or the access to materials. That is, despite the availability and ease of access to the different materials, some student-respondents expressed their financial difficulty in acquiring these.

Table 4

Summary of thematic analysis of students' identified advantages and challenges in doing FB-BLAc

Advantages and Challenges	Frequency	Examples
Practical and Improves Self-Learning	49	"The advantage is that we only use materials that are readily available at home and easy to find" (R-32) "It helped me to be independent and perform well on my own." (R-3) "It improved my confidence and helped me realize that I can do many things even if it is done individually. This helped me understand the topics further. This also taught me how to develop and construct my own objectives and conclusions. Lastly, this made me more responsible, that I should start working in order for the activities to be done." (R-16)
Issues on Resources	33	"One challenge that I always encounter is money. Though the materials needed are not too expensive or often found in our house, there are some materials that still need to be bought" (R-24) "The challenge that I have encountered was the hardship to do it within our home, because of the lack of supply and sometimes lack of appliances that hinder us, students, to do proper laboratory (activities)." (R-10)

Note: Responses were either on the advantages or challenges or both.39 out of 66 student-respondents selectively provided answers to the question: What are the advantages and challenges that you have encountered in doing FB-BLAc?

In the light of enhancing FB-BLAc, recommendations were provided by the student respondents. The responses were thematized as (1) resource -related, (2) personal related, and (3) assistance-related. The resource-related theme refers to the availability and allotment of time and materials. Personal -related theme pertains to the commitment the students must put into doing the activities including the discipline, motivation, and the anticipated struggle or enjoyment resulting from accomplishing the tasks. The assistance-related theme is construed as the rendering of assistance to

students in carrying out activities like providing video tutorials and consultations regarding students' progress. Lastly, five student-respondents have no further
recommendations for FB-BLAc and have expressed its acceptability and advantage.

Table 5
Summary of thematic analysis of students' recommendations for FB-BLAc

Recommendation	Frequency	Examples
Resource-Related	9	"I recommend to apply it easily, low cost of the material but applicable in every situation in the lesson" (R-7) "Mas maraming time pa na gawin ito (More time in doing it.)" (R-10)
Personal-Related	12	"I think this is the farthest we can go as far as the execution is involved, although, students must be more disciplined and committed to the program we are in. This is the time where we should be thriving." (R-4) "Being responsible" (R-23) "Do your best to perfect the lab test" (R-17)
Assistance-Related	4	"Consulting the students in the given activities so that it can monitor the students' development." (R-26)

Note: 30 out of 66 student-respondents provided their recommendations while three student-respondents have no recommendations and expressed the acceptability of the FB-BLAc

Additionally, a few students expressed their satisfaction and acceptability of doing FB-BLAc. Some of their responses are as follow:

"I enjoyed the FB-BLAc, it makes the online learning setup more improved." (R-2)

"All of the laboratories are student-friendly and can be performed

easily." (R-12)

"Well, I don't have any recommendation to enhance the FB-BLAc because doing these activities is fun, exciting and we see the result in our activities" (R-18)

"Um, nothing? So far FB-BLAc is doing great, especially for the students like us." (R-19)

The implementation of FB-BLAc for food and biochemistry instruction based on the aforementioned results has benefits especially in augmenting the laboratory experiences due to the remote learning setting. It is likewise plausible to utilize readily available kitchen materials to demonstrate different concepts thus facilitating instruction [20]. Beyond the advantages, students have expressed the need for assistance in the form of a demonstration or tutorial to serve as a guide which has not been a concern pre-pandemic. Also, in comparison, there have been identified differences in the performance and perceptions of students' in-person and remote access laboratory learning. Students perceive that they gain more learning and skills in the laboratory when in the presence of an instructor [21]. Understandably, with the shift from in-person to a remote type of learning, students are challenged to be more self-reliant and take actions leading to independent learning.

4 Conclusion and Recommendation

In the light of these findings, it can be concluded that the FB-BLAc is a better way of aiding instruction for food and biochemistry through the utilization of easily accessible materials. It has the benefits of promoting independent learning and enhancing science skills despite the remote laboratory setting. However, accompanying the implementation are the challenges that involve resources and the ability of students in performing the laboratory activities. By addressing these, the FB-BLAc can be utilized even for future applications in other STEM programs that will further aid in the teaching and learning of chemistry concepts whether in remote or as an aid for instruction.

Moreover, given the experience from the implementation of FB-BLAc, more specific instructions must be provided to students without compromising the open-ended feature of doing at-home laboratory activities. For chemistry instruction, this provides an improved approach of making the students explore the relationship and utility of activities together with their results to real-life situations, and realize the connections between different chemistry concepts. A better design for the implementation of FB-BLAc can be developed which will cover practicability, a wider range of topics, and alternatives for different materials.

Lastly, to strengthen the utility of FB-BLAc, the cited challenges and recommendations of students are required to be addressed. Students need to have access to preparatory video tutorials where they can make inquiries before performing the activities. It is also endorsed to study the locality in sourcing materials for each activity. This can further develop the scientific skills of students in being creative and resourceful in analyzing and utilizing other alternative materials.

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6 Conflict of Interest

The author declares no conflict of interest in this research.

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