



Regarding Collaborative Efforts among Universities, High Schools, and Boards of Education to Develop Scientific Skills

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Abstract

In order to increase high school students' interest in science and deepen their understanding, it is thought that not only regular classes but also organizational efforts in collaboration with universities and boards of education are effective. Therefore, universities, high schools, and the Board of Education have collaborated to hold a course that aims to explore the appeal of science beyond regular classes, and I would like to report on this initiative. The target schools were two schools in Saitama Prefecture, and the study was conducted for half a day. Participants were informed and recruited from the Saitama Prefectural Board of Education and the participating schools, and the content was related to cooking science, which is the specialized field of university instructors, and included instrumental measurement and measurement of the various physicochemical changes that occur during cooking. The analysis included sensory evaluation. For example, in a course on puffed cooking, we used cupcakes as the subject matter and conducted experiments to clarify the effects of different amounts of added sugar on the finished product. We started the experiment by first thinking about what kind of differences would emerge, and encouraging participants to take an observational perspective during the experiment. Objective comparative verification was carried out by observing the air bubbles in the dough using a microscope, measuring the hardness of the baked dough using a hardness meter, and measuring the color of the dough using a colorimeter. After the experiment, they explained the mechanism behind the effect of sugar on differences in leavening properties, and shared knowledge about the denaturation of egg proteins, thermal expansion of air bubbles, and the Maillard reaction. The high school students who participated were very interested in the course, which had a different structure from their regular classes, and had a high level of satisfaction after taking the course. It has been suggested that the course, which was realized through collaboration between universities, high schools, and boards of education, is effective as a system that allows students to approach science beyond the framework of academic subjects while still being based on the high school curriculum.

Keywords: Collaboration, high school, cooking science

1. Introduction

Various learning methods are used in class to increase high school students' interest in science and deepen their understanding, but it is also effective to arouse further interest and increase motivation for learning through learning that goes beyond the framework of the subject. In addition, as a method for realizing curriculum management and career education as indicated in the new course of study for high school, there is a perspective of fostering qualifications and abilities while collaborating and collaborating with society [1]. However, in order to make this a reality, there are limits to what high schools can do alone, and collaboration with outside parties is essential. The author has been working with third-year junior high school students since 2019 to explore a single theme for one year. By conducting research activities in collaboration with on-site faculty, it is possible to pursue deep learning that goes beyond the framework of regular classes and subjects, but it is important to build the foundation of a system for this purpose [2]. It would be great to be able to share some of the highly specialized learning that universities offer with high school students, but in many cases, it is difficult to link the supply and demand of both high schools and universities. I have heard that even if a high school has a request for collaboration with a university, it is difficult to directly contact university instructors with whom they have no acquaintance, and they may hesitate. In the first place, it may be unclear where universities or university instructors with the expertise to respond to requests are



located. In this way, there are few opportunities for high school and university teachers to interact with each other, and creating opportunities for collaboration is often a challenge. In such cases, one effective countermeasure would be for the board of education, which is aware of the needs of high schools, to take the lead and approach universities to promote collaboration. Promoting coordination related to collaboration by the Board of Education indicates that the foundation for collaboration between high schools and universities is stable, and will also lead to securing high-quality educational opportunities. This is considered to be a very important perspective in future education. Therefore, in order to achieve these goals, university, high schools, and boards of education collaborated to hold two special courses aimed at approaching the appeal of science that goes beyond regular classes. I would like to report on the details of these efforts, including the state of the activities and the impressions of those involved.

2. Case 1

2.1 Implementation details

Implementation date: Tuesday, August 29, 2023

Location: Toyo University Itakura Campus Cooking Room

Target: 16 students from Saitama Prefectural Sugito Agricultural High School, Food Distribution Department and Life Technology Department

Theme: Kitchen Lab: The delicious world of cooking science

Overview: Cooking science experiments on dashi soup and cupcakes, tour of university research facilities

(1) Experiment 1: Dashi (stock)

We approached the “dashi” that is familiar at Japanese dining tables from a scientific perspective, and conducted quantitative experiments using analytical equipment and reagents that are only possible at a university. Specifically, we prepared “Kombu Dashi (kelp stock)” and “Awase Dashi (mixed stock)” and investigated the difference in the amount of glutamic acid. The main purpose of this report is to summarize the students' experiences and impressions of the special courses that were realized through collaboration, as well as the impressions of those involved. Therefore, details of the experimental methods and results conducted in the course will be omitted.

【material】

A (kelp stock) 600g water, 18g kelp, 2g salt, 15mL soy sauce

B (mixed stock) 600g water, 6g kelp, 6g dried bonito flakes, 2g salt, 15mL soy sauce

A contains 3% of the total kelp, and B only 1% of the total, but we began the experiment while anticipating how this would affect the final flavor.

[Reagents and experimental equipment used]

L-glutamic acid measurement kit “Yamasa NEO”

【Method】

- ① Pour the respective amounts of water and kelp into two pots and let stand for 30 minutes (Figure 1).
- ② Take 1/2 teaspoon of the liquid and use it as a sample for measuring the amount of glutamic acid.
- ③ Heat the pot and remove the kelp just before it boils.
- ④ Turn off the heat for A (kelp stock). Measure the weight and adjust it to 600g. Set aside 1/2 teaspoon as a sample for measuring glutamic acid.
- ⑤ B (mixed stock), keep boiling without stopping the heat.
- ⑥ When it boils, add the bonito flakes and heat for 30 seconds, then turn off the heat.
- ⑦ After straining the bonito flakes, adjust the weight to 600g. Set aside 1/2 teaspoon as a sample for measuring glutamic acid.
- ⑧ Measure the amount of glutamic acid using the L-glutamic acid measurement kit “Yamasa NEO” (figure 2).



Figure 1. Soak the kelp



Figure 2. Measure glutamate



(2) Experiment 2: Cupcake

In this experiment, two types of cupcakes were made with different amounts of sugar added, and the condition of the dough and finished product were compared. We investigated how different amounts of sugar affect appearance, aroma, taste, texture, etc.

【material】

A: 50g eggs, 50g sugar, 50g soft flour, 10g milk

B: 50g eggs, 15g sugar, 50g soft flour, 10g milk

【Method】

- ① Beat the eggs with a hand mixer (high speed) for 3 minutes. Add sugar and beat for 10 seconds.
- ② Add the milk and sifted soft flour and mix with a rubber spatula in a cutting motion until the mixture is no longer powdery (Figure 3).
- ③ Divide the batter into 3 equal parts into each muffin cup.
Place a small amount of the fabric on a glass slide, cover with a cover glass, and observe under a microscope.
- ④ Bake in an oven preheated to 180°C for 15 minutes.
- ⑤ After observing the appearance, measuring the height with a caliper, measuring the hardness with a hardness meter, and measuring the color with a colorimeter, taste and record.



Figure 3. Preparing the batter



Figure 4. Cake after baking
Upper: high in sugar. Under: low in sugar

2.2 Student status and comments

In Experiment 1, it seems that the cooking operations themselves were not difficult for the high school students enrolled in a course where they had a lot of experience with cooking in their regular classes. However, this was the first time they had used the micropipette used to quantify glutamic acid, and it was impressive to see how serious they were as they practiced operating it. It was also first time to work with the unit “ μ l” and to use microplates and microplate readers. This type of experiment was one of the things that could only have been carried out in collaboration with a university. In addition, the measurement results showed that the highest amount of glutamic acid was found in the kelp stock after boiling, but the sensory evaluation showed that the umami was most felt in the kelp stock after boiling. This is due to the synergistic umami effect of glutamic acid contained in kelp and inosinic acid contained in bonito flakes. In addition to quantifying glutamic acid, the students also learned about how the taste changes when two types of umami components are combined, and the importance of evaluating food by combining objective measurement results with human senses was conveyed. When I told them that it takes effort to fully enjoy the various information that food contains using their five senses, the high school students seemed to be serious about the soup stock and focused on feeling the flavor.

In Experiment 2, the students, who are familiar with cooking, demonstrated their skills and skillfully prepared the cake. When the batter was observed under a microscope, it was found that the air bubbles were inserted in different ways, and many people were surprised to see the difference. Furthermore, the moment they took the baked cake out of the oven, they were again surprised to find that the way it swelling and the color of the cake was noticeably different.

The reason why the cake with more sugar rose better is that the air bubbles contained in the beaten eggs were stabilized in a fine state by the sugar. In addition, when amino acids and sugars react at high temperatures, an aminocarbonyl reaction (Maillard reaction) occurs, producing melanoidins, giving the food a brown color and a fragrant aroma. As a result, the color and aroma of baked goods changed depending on the amount of sugar added. When I explained the differences between the two types of cakes, I was impressed by the way they listened intently. Furthermore, when I told the students that they could control the dishes they wanted to make by scientifically understanding how food is prepared, the students looked satisfied.



2.3 Student impressions

- I used a pipette for the first time in my dashi experiment. She was able to experience the unknown quantity of microliters and learned a lot. I had a lot of fun doing experiments that I couldn't experience in high school.
- In experiments using pipettes, it was found that even a small amount can greatly affect the results. I now understand that precision is important when it comes to cooking and experimenting, so I hope to utilize this knowledge in my future dishes.
- Although I study food in my regular high school life, I was able to gain a deeper understanding through this experiment. The cupcake experiment led to me reconsidering the role of sugar, which sparked my interest in research.
- The cupcake experiment made me realize once again the importance of sugar. Even when making food for others, I found that simply reducing the amount of sugar to make it low in calories doesn't make it delicious. By understanding the role of sugar correctly, I can use it meaningfully in future dishes, which has broadened my enjoyment of cooking.
- I learned a lot because I was able to see equipment that I couldn't see at high school. I also became interested in university research. That was very fun.

3. Case 2

3.1 Implementation details

- Implementation date: Monday, December 18, 2023
- Location: Saitama Prefectural Ina Gakuen Comprehensive Upper Secondary School, cooking room
- Target: Saitama Prefectural Ina Gakuen Comprehensive Upper Secondary School, 35 second-year life science students
- Theme: Science of deliciousness ~ Approaching cupcakes ~
- Summary: Cooking science experiment related to cupcakes

The cupcake experiment method is the same as Case 1, so it will be omitted.

Before starting the experiment, the teacher asked the students what differences they thought would appear between cakes with different amounts of sugar. We then described the expected differences in as much detail as possible. Here, I encouraged the students to think on their own without consulting with others. Afterwards, there was time for each group to share their predictions. In this way, it is thought that having enough time to make predictions is effective in allowing participants to have an observational perspective during the experiment. It is hoped that experiments will be more than just work and will encourage the development of the ability to understand phenomena from a scientific perspective. In the notes written by the students who actually participated in the course, we found the following record about making predictions before starting experiments. "Be sure to make predictions before conducting an experiment → Doing so will clarify your perspective.", "Imagining and considering the results will help you develop a perspective that allows you to notice differences → You will be able to observe carefully."

3.2 Student impressions

- I was very surprised at how the finished product could change so much depending on the amount of ingredients. Also, I would have been happy if my prediction of what would happen in advance turned out to be correct, and even if it was wrong, I was able to find a new perspective. I was also able to realize the importance of thinking while working.
- I once made cupcakes and cut the amount of sugar in half because I didn't want to gain weight. I remember it being delicious at that time. In this experiment, I realized that this was the cause. I was surprised that the hardness, color, and texture could change so much just by changing the amount of sugar.
- Although there was a big difference between the two cakes, it doesn't mean that the one that didn't rise was any less delicious; both were delicious. In response, the teacher said that the cake that didn't rise didn't mean it was a failure, and I thought she was right.
- It was new to me because I had never made predictions before when cooking. As the teacher said, when I tried cooking based on my own predictions, I became more interested in the cooking process, wondering why things turn out the way they do and why things change the way they do, and I was able to do the practical training.



- I found it very interesting when I came into contact with cooking science. It was my first time trying to quantify color and measuring hardness, so I had a lot of fun trying it out. Through this class, I wanted to know more about culinary science, and I was very interested in it.
- I realized that confectionery and cooking have a lot to do with science. We used microscopes and other equipment to attend lectures in the cooking room, which I thought was a bit like taking a chemistry class and enjoyed it. Until now, I had only known about jobs such as nutritionists and cooks, but I learned that there are such fields.
- Science is often given the impression that it is difficult, but I found it very interesting and fun to do it with something familiar to me, and I was able to get a lot of interest out of it.
- Until now, we had only learned about changes in results based on chemical basis in classroom lectures, and there were many parts that were difficult to visualize. However, when we conducted this experiment, we learned a lot from observation under a microscope and various measurements.
- It was interesting to be able to immediately see the differences numerically using various specialized equipment. I learned that various physical and chemical changes are deeply involved in cooking, and that these are what create our delicious taste.

4. Views of high school teachers and boards of education regarding collaboration

4.1 What expected from the collaboration

We asked the board of education and two high school teachers involved in the collaboration to look back on this activity from three perspectives. Comments from each person are listed below.

[High school teacher ①]

First, I thought that by experiencing university classes, I would be able to clarify my career goals and expand my career options. We believe that by studying with university students, it will be easier to imagine what kind of content you will be learning at university, and there will be fewer gaps after entering university.

The second is that you can gain deep learning that is difficult to learn in high school classes. You will have the opportunity to attend live lectures from professors at the cutting edge of research and have the opportunity to ask questions directly. We also thought that it would be possible to learn experientially the skills and learning methods required after entering university.

[High school teacher ②]

For students to acquire the knowledge to conduct manufacturing training that incorporates a scientific perspective. Conduct manufacturing experiments using analytical equipment.

[Board of education]

- For students

Introducing a researcher's perspective to high school students and learning solutions based on scientific evidence

Connecting to career development by allowing students to experience university learning

- For faculty and staff

Make people realize the benefits of connecting high school and university (improved instruction, network of human resources)

knowledge update

4.2 What felt after collaboration

[High school teacher ①]

Cooking experiments can be conducted in high schools, but they do not have the equipment to analyze the experimental results or the skills to handle the equipment. For this reason, up until now, it has not been possible to conduct experimental verification using actual objects or actual experiences. This time, the university provided equipment, which enabled the students to understand the correct method of verifying experimental results, and allowed them to consider the experimental results they had seen and experienced with their own eyes.

At our school, the purpose of learning tends to be "studying to pass the entrance exam" Since the goal of learning is to get a score on a paper test, students are accustomed to studying input and output. However, I feel that many students graduate without being able to acquire the ability to set up and solve problems on their own, which is necessary after entering university. Students who are not used to learning in an independent manner tend to lack the ability to verify that they do not know the answer. I was worried that even if I could get into university, I wouldn't be able to keep up with my studies. I strongly felt that if there were more opportunities to collaborate with universities like this one, students would be able to learn active learning learning methods from high school students.



In addition, there are many things that are useful not only for students but also for high school teachers to improve their classes, and I learned a lot about how to ask questions to students, conduct experiments, and verify methods, all of which I would like to incorporate into future classes. I was able to learn how to teach students to formulate a hypothesis, experiment, and think about it, rather than just showing them the answer right away.

[High school teacher ②]

I think it was very good that the students became interested in analytical instruments, listened seriously to teacher talk, and were able to take the initiative to try to solve their own problems. I believe that thanks to teacher advice, we were able to conduct high-quality experiments. As a result, I think I was able to connect with the students themselves and have a good educational effect. I would like to request continued cooperation between high schools and universities.

[Board of education]

- To students

They found issues on their own and took initiative to solve them.

I am now able to conduct evidence-based considerations from a scientific perspective.

- For faculty and staff

They felt the effectiveness of practicing lessons from a scientific perspective.

For example, in the cooking training, we taught students not only that the food was delicious, but also had them think about the rationale behind it, which led to improvements in the lessons. I felt that this would be an opportunity to improve the quality of teaching staff.

Through this collaborative project, faculty and staff are now updating their knowledge.

4.3 What hope for in future collaboration

[High school teacher ①]

Public high schools have detailed annual lesson plans, so if you incorporate this into your lesson plans at the beginning of the school year, I think more schools will want to participate and cooperate. We believe that joint classes and joint research with university students throughout the year, rather than one-time spot collaboration, can further increase student interest. I also believe that if not only students but also high school teachers participate in university classes (rather than training for teachers), more teachers will be able to improve their classes from a new perspective.

[High school teacher ②]

Through continuous collaboration, students will become aware that experimental results from a scientific perspective are important, and will become accustomed to the process of accumulating data and summarizing experimental results.

I would like to increase the number of students who are interested in food science by thinking about collaborative content that will interest students in the main course.

[Board of education]

We will make many schools understand the significance of high school-university connections and expand the number of schools implementing them.

Classes are not one-off lessons, but deepen learning through continuous learning.

“Second Kitchen Lab” I want to connect it to continuous learning

5. In conclusion

By collaborating with high schools, universities, and the Board of Education, it has become possible to conduct highly specialized courses that go beyond academic subjects, which would be difficult to implement in regular classes alone. In the future, we plan to collect data and quantitatively analyze how students' interests and understanding have changed as a result of implementing these courses. We plan to continue this research so that we can demonstrate meaningful results as practical research.

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