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Improving the Knowledge of Deaf Students about Biotechnology: "Experience Making Kombucha"

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ABSTRACT

The goal of this study is to determine how deaf students' knowledge of biotechnology is improving. Learning how to create kombucha provides deaf students with not only experiences, but also information and awareness of the usage of microbes to produce valuable products. This study used a pre-experimental, one-group pretest-post-test design method with five deaf students as the research subjects. In the pretest, ten questions were given, followed by the teaching session on how to make kombucha, the practice of making kombucha, and the post-test. The results show that deaf students could follow the steps to make kombucha, learn about the culture of bacteria, and acquire familiarity with the role of biotechnology in solving problems and product creation. Although deaf students have difficulties learning abstract concepts, they can acquire biotechnology content as part of science by offering realistic and controlled experiences.

Keywords:
Deaf student; Biotechnology; Kombucha

1. Introduction

The Indonesian curriculum system undergoes adjustment from the 2013 curriculum to the emancipated curriculum. There are various factors pushing for changes to the Indonesian curricular system, one of which is students and technology. That is why many reports on curriculum nowadays [1-13]. The concept of the emancipated curriculum is holistic, contextual, student-centred, and exploratory in nature. Furthermore, it is thoroughly described in the Decree of the Minister of Education, Culture, Research, and Technology Number 56/M/2022 that the principles of the independent curriculum are:

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i. learning is designed by considering the current stage of development and level of student achievement, in accordance with learning needs, and reflects the characteristics and development of diverse students. Thus, learning becomes meaningful and enjoyable
ii. learning is designed and implemented to build capacity to become lifelong learners
iii. The learning process supports the development of students' competencies and character holistically
iv. Relevant learning is learning designed according to the context, environment, and culture of students and involves parents and communities as partners
v. Sustainable future-oriented learning.

One of the advantages of emancipated curriculum is the Pancasila Student Profile (P5) Project. Pancasila is one of the important values in Indonesia [14]. P5 is a novel concept in Indonesian education. Several major themes or problems are chosen and implemented by each school unit in the P5 project [15]. The themes for P5 have been regulated by the government [16], and entrepreneurship is one of the themes. In entrepreneurship theme, students can learn and practice current materials in a project-based learning to produce work of selling value, followed by the process of analysing the results of student activities.

Research on natural science material related to biology that has been carried out has focused on strengthening science process skills in students with intellectual disabilities using photosynthesis [17,18]. The learning material provided was biotechnology that had been simplified into the form of common applications in everyday life, which can later become soft skills for the students, such as making tempeh, coconut gel, yoghurt, fermented cassava, and so on. Students frequently encounter some examples of these products in daily life. As a result, the researcher investigated biotechnology materials for deaf students. In this study, researchers provided an explanation of the fermentation of kombucha drinks and the steps for making consumable kombucha since kombucha is rich in benefits and the raw materials used are very simple and easy to find by students. So, this study aims to increase students' knowledge about biotechnology by directly practicing how to make kombucha.

Research on natural science material related to biology that has been carried out focused strengthening science process skills in students with intellectual disabilities using photosynthesis [18]. The learning material provided was biotechnology that had been simplified into the form of common applications in everyday life which can later become soft skills for the students such as making tempeh, coconut gel, yoghurt, fermented cassava, and so on. Some examples of these products have often been encountered by students in everyday life. As a result, the researcher investigated biotechnology materials for deaf students. In this study, researchers provided an explanation of the fermentation of kombucha drinks and the steps for making consumable kombucha since kombucha is rich in benefits and the raw materials used are very simple and easy to find by students. So, this study aims to increase students' knowledge about biotechnology by directly practicing how to make kombucha.

2. Methodology

This study used a pretest, treatment, post-test design. It signifies that there was no control group in this study. The study's subjects were five deaf senior high school students in special education. The study only included five deaf students because the number of deaf pupils in a school was quite low. This research was carried out in the following stages:

i. Pretest
ii. Providing a power point on biotechnology content
iii. showing a video on how to create kombucha
iv. participating in the process of creating kombucha
v. post-test to measure the subject's comprehension of the material presented
vi. assessing the activity of deaf students seeking for baby SCOBY on the top of kombucha.

The following ten questions were included in the pre-test and post-test to evaluate deaf students' abilities:

i. Have you ever learned about organism?
ii. Please write down the organism that you know!
iii. What is biotechnology?
iv. What is microorganism?
v. What is fermentation?
vi. Please write down an example of fermentation product!
vii. Please write down where you found the fermentation product!
viii. What is kombucha?
ix. Please write down how to make kombucha!
x. Please write down the benefits of kombucha! Data collection on the knowledge used scoring rubric in which correct answer received 10 points, and false or no answer received 0 point.

The researcher explained to students about biotechnology and provided examples of biotechnology products, namely tempeh, fermented cassava, coconut gel, and yoghurt. After the students understood that the everyday products were the result of fermentation, the researcher introduced kombucha. Students observed and participated in the kombucha-making process. The kombucha-making method is separated into four stages: stage 1, preparing tools and ingredients; stage 2, making sweet tea; stage 3, making kombucha; and stage 4, harvesting. A task analysis describes each point. Each stage was described in a task analysis. Task analysis was needed to see the ability of deaf students' skills. Task analysis was a component of the procedure of breaking down skills into sub-skills so that they could be observed to complete tasks. If the student could identify or knew the object shown, he or she would be given a checklist.

Stage 1 Preparing tools and materials:

i. Students know the scales
ii. Students know the kettle
iii. Students know the sifters
iv. Students know tongs
v. Students know measuring cups
vi. Students know spoons
vii. Students know plates
viii. Students know the jar
ix. Students know about cotton fabric
x. Students know rubber
xi. Students know black tea
xii. Students know granulated sugar

xiii. Students know hot water
xiv. Students know SCOBY
xv. Students know the starter.

Stage 2 Making sweet tea:

i. Students are able to weigh 5 grams of black tea
ii. Students are able to weigh 150 grams of sugar
iii. Students are able to weigh 250 ml of hot water
iv. Students are able to prepare 1250 ml of water
v. Students are able to prepare the kettle
vi. Students are able to prepare spoons
vii. Students are able to prepare a filter
viii. Students are able to pour the weighed tea into the kettle
ix. Students can pour hot water into the kettle
x. Students are able to stir tea with a spoon
xi. Students are able to filter tea
xii. Students can put sugar into filtered tea
xiii. Students are able to stir the sugar until it dissolves.

Stage 3 kombucha-making process:

i. Students are able to prepare a sterile jar
ii. Students are able to prepare sterile tongs
iii. Students are able to prepare sterile plastic spoons
iv. The student is able to prepare a sterile covering
v. Students are able to prepare a starter
vi. Students are able to put the starter into the jar
vii. The student is able to put the SCOBY into the jar
viii. Students are able to put sweet tea into the jar
ix. Students can stir kombucha using a plastic spoon
x. Students can cover the jar with a cotton cloth
xi. Students are able to put kombucha in a safe place.

Stage 4 Harvesting:

i. Students are able to prepare 250 ml of sterile bottle
ii. Students are able to open the cover of the jar
iii. Students are able to clamp the SCOBY and move to the plate
iv. Students are able to filter the kombucha
v. Students are able to pack the kombucha into the 250 ml of bottle
vi. Students are able to keep kombucha in the chiller.

During the process of making kombucha, the researcher also taught how to weigh and unit weight with manual kitchen scales and the position of the needle when it is at 100 grams and 5 grams. In addition to heavy periods, the researcher also taught the use of measuring cups in millilitres. Students were taught how to measure water up to 1250 ml.

The process of producing kombucha took 10 to 14 days. After 10–14 days of fermentation, the new SCOBY or baby SCOBY would reach a thickness of 2 cm [19]. Every day, the students were asked to pay attention to the growth of baby SCOBY and the process of kombucha development from day to day. The students were asked the questions:

i. What did you see?
ii. Do you smell something?
iii. Are you happy? And do you visit the Laboratorium to see Kombucha?

The illustration of the making of kombucha is shown in Figure 1.

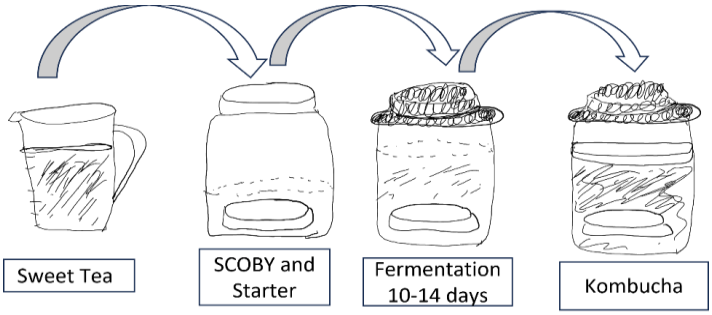

Fig. 1. Illustration of making kombucha

3. Results and Discussion

3.1 Student's Demographic Data

Five deaf students from special schools participated in this study: RR, OZ, VD, MN, and SO. RR communicated with teachers and friends through sign spoken communication. OZ still used mother sign language because could not use the Indonesian Sign System (CIBI). CIBI is a sign language that has been standardized by the government [20]. VD students use Indonesian sign language (BISINDO), which is gesture recognition for Indonesian sign language. In Indonesia, there are two types of sign language, namely the Indonesian Signal System (SIBI) and Indonesian Sign Language (BISINDO) [21]. MN communicated using their mother tongue and was new to the SIBI sign language alphabet. However, MN could understand lip language if teachers and friends spoke with clear and slow articulation. Furthermore, SO was the same as MN, using mother tongue sign language and paying attention to lip movements.

3.2 Experiments Results

Biotechnology is the study of the use of living things, both microbes and macroorganisms. Biotechnology is classified into two types: conventional biotechnology and modern biotechnology. Conventional biotechnology entails using intact microorganisms directly without any engineering processes and employing simple techniques. In everyday life, this is referred to as fermentation. Fermentation is the process of producing a product using microorganisms, one of which is bacteria. Fermentation is the breakdown of organic compounds by microbes in a controlled environment, utilizing enzymes produced as biocatalysts. Microbes, substrates, and fermenters were all necessary during the fermentation process.

The study focused on kombucha, a fermented tea. Kombucha is a fermented tea drink created with SCOBY (Symbolic Culture of Bacteria and Yeasts). Acetobacter xylinum and yeasts such as

Saccharomyces cerevisiae, Zygosaccharomyces baili, and Candida sp. are among the microorganisms found in SCOBY. Acetobacter xylinum secretes a polymerase enzyme that can transform glucose molecules into cellulose polysaccharides. It's easy to observe in Figure 2.

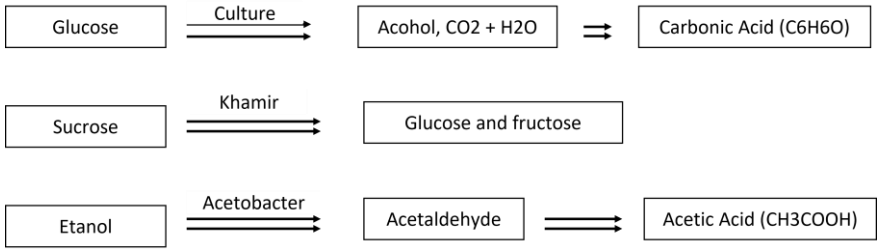

Fig. 2. The process of kombucha fermentation

3.3 Conventional Biotechnology

Table 1 demonstrates how deaf students perceive the use of biotechnology in the production of kombucha. During the pre-test, RR, OZ, VD, and MN students scored 20 since they answered two questions correctly out of ten. SO did not respond to questions, they receive a grade of 0. In addition, the teacher provided students with information on biotechnology, fermentation, and how to brew kombucha. When the teacher described fermentation to the students, they were all intrigued. After being given instances of fermentation, such as tempeh, fermented cassava, and yoghurt, VD responded, "Oh, is the tempeh in the house fermented?". The teacher then responded to the statement, "Right.". "Everything is fermented," stated the RR student. The teacher said, "Right."

Furthermore, the teacher explained that fermentation is assisted by good bacteria. MN say "bacteria are good?" and VD say "there are". After giving examples of fermented products that students have often encountered, the teacher then showed kombucha to the students. OZ asked "what is ma'am?" the teacher replied "this is fermented tea called kombucha". RR asked, "is that medicine?" the teacher replied "this is not medicine but a healthy drink, kombucha is good for our gut health". Then VD asked "if we drink this, our gut is healthy?" the teacher replied "yes that's right, besides, kombucha is also good for our immune system, keeping us healthy". Next, the teacher explained the benefits of kombucha that it had anticancer, antimicrobial, and antifungal properties as well as hepatoprotective effects [22]. Kombucha contains one of the components that plays a role in liver destabilization so that it can improve liver function [23]. The benefits of kombucha are due to the presence of probiotic microorganisms, antibiotics, amino acids, polyphenols from tea, sugar, organic acids, ethanol, water-soluble vitamins, and various micronutrients resulting from fermentation [24].

Table 1
Comparison of the pretest and post-test results

No	Subject	Before Explain the Material	After Explain the Material
1	RR	20	80
2	0Z	20	70
3	VD	20	90
4	MN	20	80
5	SO	0	60

3.4 Teaching Process

The task analysis of deaf students when producing kombucha is described in Table 2. RR, OZ, and SO were unfamiliar with the scales throughout the early stages of preparing equipment and materials since they had never seen them previously. While the VD claimed to have seen it in a stall and the MN student claimed to have found the scales in his or her house. The students are familiar with various instruments such as kettles, sifters, tongs, spoons, plates, cotton fabric, and rubber. These items are frequently discovered in their home. However, the students are unfamiliar with measuring cups since they have never seen them. Furthermore, RR and MN learned that Jar was spotted at an ice seller's location, while OZ, VD, and SO never saw it. RR could recognize black tea, while OZ, VD, MN, and SO did not know the black tea since it is in the form of powder instead of tea bags they had seen at home. Because they routinely make tea at home, they are already acquainted with hot water and granulated sugar. However, because all students are unfamiliar with SCOBY and starters, they need further explanation. Students quickly discover the tools and materials during the encounter.

Furthermore, Table 2 explains the students' abilities in the process of making sweet tea. MN could weigh as much as 5 grams of tea. However, RR, OZ, VD, and SO could not weigh tea because they did not know how to do so. RR, OZ, VD, MN, and SO could could weigh sugar because they already know how to weigh and they did it alternately. At the time of measuring hot water, VD asked the teacher, "Is it the same as weighing? The teacher replied, "No." Then VD noticed the measuring cup and said, "Oh yes, I know." VD measured hot water by paying attention to the numbers on the measuring cup. The action was followed by RR and MN. Meanwhile, OZ and SO was not able to do it because they did not pay attention to other students when performing. After being explained by the teacher, RR, OZ, VD, MN, and SO could measure water to as much as 1250 ml. Later, all students could prepare kettles, spoons, and filters. RR, OZ, VD, MN, and SO were able to put the tea into the kettle, stir the tea with a spoon, filter the tea, and stir the sugar until it dissolved in the tea water.

In the process of making kombucha, students were very enthusiastic and did it meticulously. RR, OZ, VD, MN, and SO could prepare jars, barrels, plastic spoons, and coverings sterilely. Next, students tried to pick up and clamp SCOBY to put in the jar. However, VD and RR found it a little difficult because SCOBY was slimy and difficult to clamp. However, after trying and being helped by friends, VD and RR were able to overcome their difficulties. All students could put the sweet tea into the jar and cover it until it was stored in a safe place. In this activity, students could cooperate and helped each other. This collaboration must be cultivated in the process of learning and teaching.

The harvesting process was the process the students were waiting for because they had been waiting for 13 days. Students felt very happy and excited about preparing 250-ml bottles to store the harvested kombucha. Students carefully opened the lid of the jar. Students clamped the SCOBY and moved it onto a plate. RR, OZ, VD, MN, and SO had a little trouble clamping SCOBY because it was slimy. Students needed the teacher's help to hold the jar so the SCOBY could be removed. Students could perform well sifting kombucha and packing it into bottles. Students could also store kombucha in the refrigerator.

Table 2
Task analysis of the process of making kombucha

Question	Subject				
	RR	OZ	VD	MN	SO
Stage 1: Prepare tools and materials					
i. Students know the scales	-	-	√	√	-
ii. The student knows the kettle	√	√	√	√	√
iii. Students know the sifters	√	√	√	√	√
iv. Students know tongs	√	√	√	√	√
v. Students know measuring cups	-	-	-	-	-
vi. Students know spoons	√	√	√	√	√
vii. Students know plate	√	√	√	√	√
viii. Students know the jar	√	-	-	√	-
ix. Students know about cotton fabric	√	√	√	√	√
x. Students know rubber	√	√	√	√	√
xi. Students know black tea	√	-	-	-	-
xii. Students know granulated sugar	√	√	√	√	√
xiii. Students know hot water	√	√	√	√	√
xiv. Students know SCOBY	-	-	-	-	-
xv. Students know the starter	-	-	-	-	-
Stage 2: Process of making sweet tea					
1. Students are able to weigh 5 grams of black tea	-	-	-	√	-
2. Students are able to weigh 150 grams of sugar		√	-	√	√	-
3. Students are able to prepare 250 ml of hot water	√	-	√	√	-
4. Students are able to prepare 1250 ml of water	√	-	√	√	-
5. Students are able to prepare the kettle	√	√	√	√	√
6. Students are able to prepare spoons	√	√	√	√	√
7. Students are able to prepare a filter	√	√	√	√	√
8. Students are able to pour the weighed tea into the kettle	√	√	√	√	√
9. Students can pour hot water into the kettle	√	√	√	√	√
10. Students are able to stir tea with a spoon	√	√	√	√	√
11. Students are able to filter tea	√	√	√	√	√
12. Students can put sugar into filtered tea	√	√	√	√	√
13. Students are able to stir the sugar until it dissolves	√	√	√	√	√
14. Stage 2: Process of making sweet tea					
15. Students are able to weigh 5 grams of black tea	-	-	-	√	-
Stage 3: Kombucha making proses					
1. Students are able to prepare sterile jar	√	√	√	√	√
2. Students are able to prepare sterile tongs	√	√	√	√	√
3. Students are able to prepare sterile plastic spoons	√	√	√	√	√
4. The student is able to prepare a sterile covering	√	√	√	√	√
5. Students are able to prepare a starter	√	√	√	√	√
6. Students are able to put the starter into the jar	√	√	√	√	√
7. The student is able to put the SCOBY into the jar	√	√	√	√	√
8. Students are able to put sweet tea into the jar	√	√	√	√	√
9. Students can stir Kombucha using a plastic spoon	√	√	√	√	√
10. Students can cover the jar with a cotton cloth	√	√	√	√	√
11. Students are able to put Kombucha in a safe place	√	√	√	√	√
Stage 4: Proses of harvesting					
1. Students are able to prepare 250 ml of sterile bottle	√	√	√	√	√
2. Students are able to open the cover of jar	√	√	√	√	√
3. Students are able to clamping of SCOBY and to move to the plate	√	√	√	√	√
4. Students are able to filter the Kombucha	√	√	√	√	√
5. Students are able to packing the Kombucha into the 250 ml of bottle	√	√	√	√	√
6. Students are able to keeping Kombucha into the chiller	√	√	√	√	√

The most intriguing aspect of producing kombucha is the 13-day harvesting procedure. This activity can train students' patience and responsibility. Students have to wait and keep kombucha from being held or disturbed by other students. Starting on the second day, students visited the room where kombucha was stored during recess. On the third day, baby SCOBY began to appear and thicken. The teacher asked the students, "What are you looking at?" VD replied, "There is a baby SCOBY, but it's still small." Continued by RR and MN saying, "Yes, there is, but small." While OZ and SO asked, "What is this, ma'am?" the teacher replied, "This is baby Scoby." On the eighth day, baby SCOBY had thickened, and a white layer had appeared like white jelly. VD responded when he first saw, "Wow, it's thick; there's a strong smell," and asked, "What smells, ma'am?" The teacher replied, "It smells of kombucha." The VD said to RR, "This Tuesday the kombucha can be tried," then RR asked, "Why wait for Tuesday?" VD replied, "Because today's kombucha is still small." MN asked RR, "Can we drink it?" RR replied, "We don't know yet; let's see." VD asked the teacher, "Ma'am, what does it taste like?" The teacher replied, "It's delicious." Then VD said, "Now the little Kombucha can't be drunk; maybe later, when it grows up, it can be even better.".

After harvesting, students took turns tasting the kombucha. At first, students refused to taste it because of the smell of kombucha that they were not familiar with. VD asked the teacher, "What does it taste like?" The teacher drank Kombucha and said, "Delicious." Because VD was curious, he or she tried and was surprised, saying, "Wow, delicious." VD told the other students "It is your turn." and thenRR, OZ, MN, and SO tried it in turn. VD, SO, and MN asked the teacher, "Mom, will we make it again tomorrow?" The teacher replied, "Yes, we will make it again. Do you want to?", RR replied, "Yes, I want." Next, the teacher asked, "Are you happy?" All the students nodded in unison and said "happy.".

This study gives information for further development as reported elsewhere regarding several subjects:

i. Mathematics [25-52]
ii. Biology [53-62]
iii. Physics [63-67]
iv. Chemistry [68-74]
v. Engineering [75-80]

Besides, this research shows that the experience of making kombucha can be said as an innovative method for improving students' abilities. Teaching innovation and student employability were mentioned prominently, indicating recognition of the importance of innovative teaching methods to enhance the educational experience [81].

4. Conclusions

The results demonstrated that deaf students could follow the steps for making kombucha, understood bacteria culture, and gain experience with biotechnology to solve problems and create useful products. Although having in learning abstract concepts, by providing concrete and structured experiences, deaf students can acquire biotechnology as part of science.

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