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TEACHING "NANOTECHNOLOGY" FOR ELEMENTARY STUDENTS WITH DEAF AND HARD OF HEARING

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Abstract

The present study aims to reveal how to teach basic nanotechnology in daily life to students with deaf and hard of hearing (DHH). The study used a single-subject research approach in one special needs elementary school in Bandung (i.e., four students with DHH using pre- and post-test). The teaching was delivered using a bilingual method (i.e., sign and writing-and-speaking methods) completed with experimental demonstration. The results revealed that difficult subject (such as nanotechnology) could be taught to DHH students. However, the main key point is the way how to deliver the subject. The additional experimental demonstration is effective to boost the level of students' understanding. In addition, the surrounding factors (i.e., light brightness) have a great impact for DHH students to understand what the teacher has articulated during the teaching and learning process as they relied on reading the lip movements of the teacher.

Keywords: Deaf and hard of hearing, Elementary student, Light brightness, Nanoscience, Teaching,

1. Introduction

Nanotechnology is the branch of science and technology conducted at the nanoscale or a billionth of a meter. Nanotechnology first appeared in the modern era [1]. Now, it has shown a significant development as the awareness of society enhances [2].

To sustain the research and development of nanotechnology for the future, many countries have raced to inject the principle of nanotechnology in school [3-5]. The development of nanotechnology in school, basically, needs to be based on a robust understanding on the subject structures and behavior in the basic level, including the importance of nanotechnology in daily life [6]. Many researchers believed that introduction of nanotechnology in school can enhance students' curiosity from the beginning [7]. Indeed, this can bear new creations and further implementations of nanotechnology for wider range of applications. However, problems rise where students find it difficult to understand the scientific principles that underlie nanotechnology and its unique properties of nanoscale material [8]. Previous studies showed that some challenges in teaching nanotechnology and level of students' comprehension are because of the following parameters: lack of teachers' knowledge of the subject, limited learning resources and tools, teachers' lack of professional training related to teaching nanotechnology for students [9]. Therefore, combination between competent teachers and effective teaching methods are required to find a way to simplify the complexities in nanotechnology.

A number of studies show that visual techniques would be effective to simplify the teaching of nanotechnology [10]. Complex laboratory reports can be modified to make them simpler and easier to be applied and practiced by students in their laboratory activities and in their daily life [11]. On the other report, the use of interactive learning video consisting of attractive visuals on nanotechnology added with online learning activities, for example, offers meaningful opportunities for students to improve understanding on nanotechnology concepts and to create new learning experiences that support teaching innovations in the field of nanoscience [7, 12]. In addition, although many methods have been implemented the subject of nanotechnology in schools, it is rare to find how to teach it comprehensively [13], giving homework for scientists, practitioners, and educators.

Further, even though reports on how to introduce nanotechnology to elementary, junior, and high school students have been started and well-documented, studies related to teaching nanotechnology for students with special needs, particularly deaf and hard of hearing (DHH) students, are hardly to find. Studies on teaching DHH students are limited only to simple subject. Indeed, the teaching must be completed with several teaching strategies [14-16]. In fact, citizens who have physical, emotional, mental, and social disabilities have the rights to get education without restrictions and limitations. Thus, any subjects must be delivered well.

Teaching DHH students is a controversial issue, especially when it relates to teaching a complex subject. This is because of its limitation in delivering subject and the IQ level of DHH students [17, 18], giving a significant concern to find what strategy to give the best teaching method for them, whether the students should be taught in regular schools with other students or in special schools that offer special education for DHH students [19]. Further, to teach nanotechnology as a difficult subject to DHH students, it is important to consider some findings that academic achievements of DHH students result from a complex interaction of at least three factors, including (i) students' characteristics with limited hearings, language, and communication functions; (ii) parents' educational backgrounds and social economic status; and (iii) students' experiences inside and outside their schools and peer relationship [20]. That is the main reason why reports on the teaching nano to DHH students are rarely find because researchers will face two barriers: one is the nanotechnology itself as the difficult subject, and the other is the students as the subject that have unique characteristics. Therefore, to minimize the limitation of teaching and learning process (due to the existence of the barriers), we limited the discussion about the importance of nanotechnology in daily life.

Here, based on our experiences in nanotechnology [21-26] the purpose of this study was to report on how to teach nanotechnology to students with DHH. This study is significantly important because even though some reports have shown a method for teaching nanotechnology to elementary school students, studies related to teaching nanotechnology for DHH students are hardly to find.

In addition, until now, the best method to teach the DHH students are using bilingual method [15, 27]. However, we found that instructions to DHH students by this method are not so much effective for teaching nanotechnology. Therefore, additional attractive experimental demonstration will help in boosting DHH students' comprehension (attracting DHH student attention during teaching process). Providing instructions to DHH students requires a special treatment and is influenced by environment, the present study also investigated how to teach nanotechnology to DHH students using various levels of light brightness (as a main environmental factor).

2. Logical Framework of Nanotechnology in Solute Dissolution

Nanotechnology has a quite large area of disciplines. However, to teach nanotechnology in the elementary level, subject must be done in the basic level of understanding. Giving too high level of nanotechnology will give student difficult to understand. As an example of teaching nanotechnology to the elementary students, this study was focused on the teaching effect of particle size on dilution process, in which this dilution process can be found in students' daily life.

Figure 1 shows the illustration of the dilution process. For the normal elementary students, the logical thinking on how to the dilute solute (such as sugar and salt) into solvent (such as water) has been built, Fig. 1(a). They are well-understood that the solute will disperse into the solvent homogenously. Indeed, their understanding is without deep understanding on phenomena in the chemistry subject (such as ion formation, critical solute concentration, etc.), in which these will be further taught when they reach senior high school level. Then, they also understand that small particles are easily dissolved into the aqueous solution. This can be explained easily to the students by a simple explanation about dividing cube of sugar with the simple mathematical analysis of surface area, Fig. 1(b). In short, students can follow that the smaller particles have a direct correlation to the larger surface area and the dissolution process. However, teaching these phenomena to DHH students will need further consideration and specific treatment.

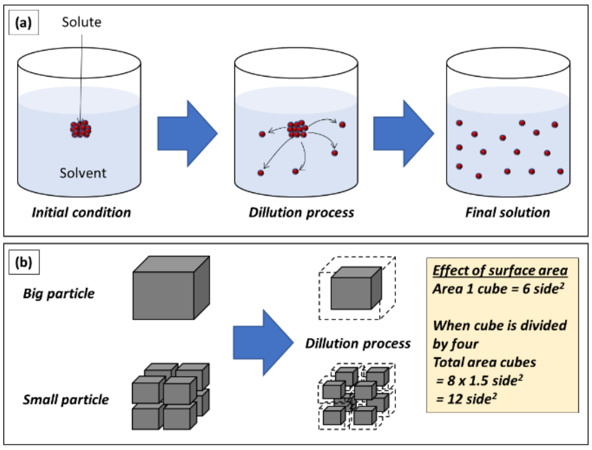

Fig. 1. Illustration of dilution of sugar/salt in the aqueous solution (a) and its correlation with the definition of surface area (b).

3. Research Methodology

3.1. Research subject

This study used a single-subject research approach, which focuses more on limited research subjects (i.e., nanotechnology subject) and can be replicated for future research [28]. The participants of the study were four DHH students at Al-Hikmah special needs education elementary school in Bandung, Indonesia. This school is only for special need students; In other words, the DHH students are not blended with the normal students in the teaching and learning process. For the teaching, we delivered bilingual method (sign language and writing-and-speaking method) [27]. Then, for improving student comprehension, we completed the teaching with a simple experimental demonstration.

In addition, to get basic information of the students, such as IQ level, demographic information, and their basic knowledge ability (i.e., mathematics, social science, basic science, Indonesian language, and Islamic religion), interview to the school teacher was conducted. The collected data were then used to develop research instruments. To simplify the analysis of the level of students' ability, all information was assessed using 6-scale score from 0 (knowing nothing), 1 (very poor), 2 (poor), 3 (middle), 4 (good), 5 (very good), and 6 (excellent).

3.2. Teaching condition

Teaching was conducted in six courses. Each teaching course was done in 45 minutes class and uses different light brightness by changing LED (Light Emitting Diode) lamps (i.e., 5, 10, 15, 20, and 40 W) in the class to gather additional information about the effect of light brightness in the learning process. To simplify the teaching process of nanotechnology, we deliver information only about nanotechnology in daily life: i.e., the effect of particle size on the dissolution process in water. To get information the student comprehension, the teaching process was completed with pre- and post-test (via interview).

The first lecture taught students with the important of nanotechnology in daily life (e.g. why gecko can walk on wall and ceiling, what the effect size of sugar/salt used on cooking or making cup of tea, etc), whereas the other lecture was experimental demonstration of sugar/salt dissolution process. The experimental demonstration was to give understanding why small sugar/salt particles are able to dissolve in water.

In addition, in the experimental demonstration, we used lamp that used in the common teaching classroom (20 W). However, for the first lecture regarding explanation of nanotechnology, lamps were varied.

3.3. Experimental demonstration

The experimental demonstration was conducted in the 300-mL beaker glass. We used various types of commercial sugar: irregular rock sugar (sizes of about 20 mm), powdered sugar (sizes of about 0.010 mm (~10,000 nm)), and syrup (various colored sugar). We also used various types of commercial salt: irregular pellet salt (sizes of about 20 mm) and powdered table salt (sizes of about 0.010 mm (~10,000 nm)).

In the typical demonstration, 2 table spoons of sugar/salt with a specific size were put into the beaker glass, poured with drinking water, and stirred with a table spoon. During the stirring, the student investigated the effect of sugar/salt size on the dissolution process (salt/sugar dissolved into the water). We also varied the drinking water: hot water (temperature of about 70°C) and cool water (temperature of about 25°C).

4. Results and discussion

4.1. Students' demographic data

Demographic data of DHH students is shown in Fig. 2. The figure showed six basic information from the students ranging from 8 to 9 years old, such as DHH diagnosis, dyslexia diagnosis, level of hearing loss, student ability to use sign language, ability to speak in clarity, and ability to understand others. This information is required to understand the IQ level of DHH students, in which this will give impact to students' comprehension.

Student #1 is diagnosed to have DHH in level 4, meaning that student's basic listening and speaking skill in good level. Meanwhile, the level of dyslexia diagnosis showed a level 3 indicating that ability to process information and pouring ideas in the writing needed to have special intervention from teachers. Besides, this student showed a good level of hearing, but had low ability in speaking and understanding others.

Student #2 had been diagnosed to have similar level of DHH diagnosis to student #1. The student had demonstrated a low level of dyslexia, speaking ability, and sign language ability. Meanwhile, the understanding ability of the student indicated the lowest.

Students #3 and #4 had been diagnosed for DHH with level 3. However, student #3 had lower level in dyslexia diagnosis than student #4, which is due to the absence of parental support in student learning at home. Both had similar level of hearing loss. In the case of speaking ability, student #3 had more vocabulary and could speak clearer than student #4. Thus, student #3 had better ability to understand others.

Based on these characteristics, the intelligence level of student can be distinguished. From the best to the lowest grade, we can rank students as students #1, #3, #4, and #2.

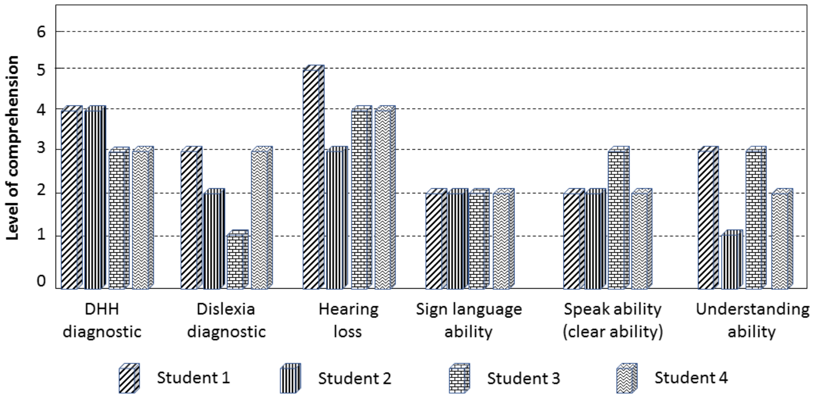

Fig. 2. Demographic data of DHH students.

The analysis showed that the average IQ levels of the students were below than 70, indicating that the students had intellectual disabilities. Individuals with low IQ demonstrate several characteristics, such as having a slow information processing, finding some difficulties to comprehend learning subjects with abstract concepts, and having problems in social interactions [29]. Thus, additional special treatment will be required to deliver subject to the students. The above demographic data were also used as a reference to perform the next test of the effect of IQ towards students' comprehension on subjects (i.e., mathematics, science, social science, Indonesian language (as their mother language), and religion).

The testing results of four DHH students on basic knowledge are shown in Fig. 3. Different characteristics among students are found. Student #1 and #2 had more interest in social science subject than other subjects. Student #3 who had better comprehension than others showed interest to mathematics, Indonesian language, and religion. Meanwhile, student #4 showed lack of interest to any subjects, particularly Indonesian language. But, teachers found the student #4 interested in religion subject. Although there is a relation with the IQ of the student, the effect is not so huge. The result confirmed that the interest in one subject than another seems to be from student's curiosity and contentment.

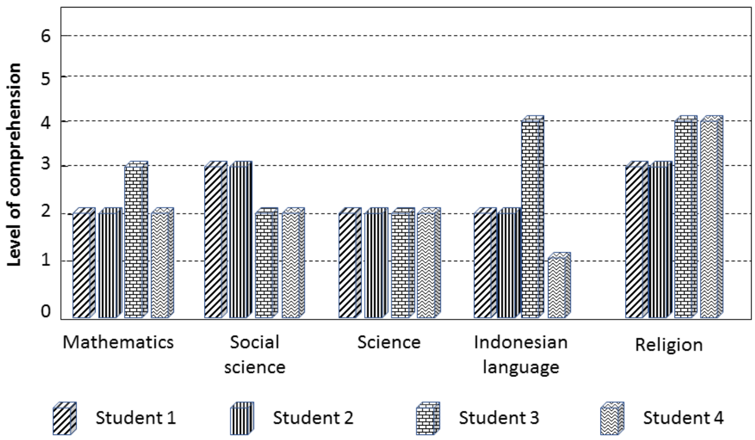

Fig. 3. Level of students' comprehension on subjects.

4.2. Teaching nanotechnology to DHH students

Based on the above demographic data as well as IQ and basic knowledge of the students, we found complexities of DHH students' learning to gain academic achievements. Thus, we limited to implementing a basic nanotechnology in daily life as a main teaching subject. At least, the investigation can give the students understanding the basic concepts of what nanotechnology is.

The results revealed that nanotechnology could be taught to DHH students. Since DHH students have low IQ level compared to other normal students [18, 30], teachers must be skillful in teaching topic relating to technology so that students' level of understanding improves. Special technique for teaching is also required because the focus and the concentration of DHH students for learning something is limited and easy to be destructed. Thus, they can not absorb effectively using usual teaching and learning process.

After delivering the nanotechnology subject, we found that

(i) In the initial course, since the teaching was delivered by bilingual method (i.e., sign and writing-and-speaking method), students seemed to be not interested. Level of understanding student is questionable.

(ii) Additional simple experimental demonstration attracts students' attention. Indeed, this increases students' interest. Specifically, when diluting sugar with different colors of syrup. Students also tasted the diluted sugar/salt in water.

(iii) Additional simple experimental demonstration improves level of students' comprehension, compared to conventional teaching with bilingual method only.

(iv) The results showed that IQ level did not significantly affected the level of students' comprehension towards the subjects. The way on how to teach is significantly effective to increase students' comprehension.

From the above results, the teaching process for DHH student required a special technique. Specifically, teacher needs to give attractive method for attracting student concentration and focuses. Otherwise, level of student understanding is unpredictable.

To ensure the level of students' comprehension during the teaching process, the final test about nanotechnology were given to DHH students from basic to medium level of questions. Table 1 shows some questions related to nanotechnology that was administered to students. As a model, we asked seven questions. More specifically, the questions related to the sugar and salt dissolution process. To confirm the impact of additional experimental demonstration on the improvement of students' comprehension, we compared the result of teaching process with (w) and without (w/o) additional experimental demonstration.

The test shows that DHH students found it difficult to comprehend basic samples of nanotechnology. All students show minimum score of the questions. The top score was found for student #3, which has score 3 for middle understanding. However, we found that additional experimental demonstration is prospective to improve students' comprehension, shown by the increasing level of student understanding to the value of 3.

To clarify the main reason for the low score of understanding, we can compare with the results in Fig. 3. As shown in Fig 3, all students had low comprehension in science, shown by the poor range of score in science. Since nanotechnology is dominated by science, the level of students' comprehension has no relation with objection from students. Indeed, this was also confirmed by the actual condition that all students give their best attention for the teaching and learning process.

The other reason for the low score of understanding is due to students' limitation (as shown in Fig. 2). We found that the result in Table 1 is in a good correlation with the barrier in understanding ability. Student who had average level of speaking ability and understanding the concept of nanotechnology was student #3. Meanwhile, student #2 demonstrated the lowest level of understanding the concept because the student had poor level of speaking ability.

To increase the level of understanding, teacher must repeat many times the teaching topics since their comprehension correlates with repetition in communication. The way how to perform repetition could also be conducted in experiment. Indeed, support from the simple experimental demonstration helps much for increasing the level of understanding.

Table 1. Questions on nanotechnology to DHH students.

Questions		Students' comprehension*							
		#1		#2		#3		#4	
		w/o	w	w/o	w	w/o	w	w/o	W
1	Does the solvent relate to the size of salt or sugar particles?	1	2	1	2	2	3	1	2
2	Do we need to stir for dissolving salt or sugar particles?	1	2	1	2	2	3	1	2
3	Do we need to boil for dissolving salt or sugar particles?	1	2	1	2	1	2	1	1
4	What is the importance of stirring on the dissolution of salt particles?	1	2	1	2	3	3	1	3
5	What is the importance of heating for dissolving salt?	1	2	1	1	1	2	1	1
6	What is application of nanotechnology in daily life	1	1	1	1	1	2	1	1
7	What is relation of surface area and dissolution of salt or sugar particles	1	1	1	1	1	2	1	1

Note: *students' comprehension with and without experimental demonstration. w/o = "without" experimental demonstration. w = "with" experimental demonstration

4.3. Surrounding factor (light brightness) on the successful teaching

To examine the effect of light brightness towards the learning process of nanotechnology, we used teaching test with different levels of brightness of lamps (from 0 to 40 Watt lamps) (viz Fig. 4). The results showed that students' comprehension on nanotechnology subject varied along with the changes in light brightness.

When using 0 and 10-Watt lamp, students did not catch the teaching subject. The level of comprehension for students #2 and #4 is zero, whereas students #1 and

#3 accept less teaching and learning process. Our investigation confirmed that the light brightness creates problems in the physiological condition of the most DHH students. However, the higher intelligence level promotes better self-control of the student attitude and behavior.

In the case of light brightness of 15 Watt, the level of understanding improved to some students. The students started to listen what teacher described in front of the class. It is found that student #3 had the highest comprehension compared to the other students. Meanwhile, student #1 demonstrated similar comprehension from the previous light brightness. The main reason is that the student #1 was not in a good mood for listening the teacher because the surrounding condition was noisy, disturbing students' focus and decreasing their concentration.

Some level of comprehension changes occurred when more than 15-Watt lamp was used. When using 25-Watt lamp, student #1 experienced the highest improvement in comprehension compared to the other students. In this condition, student #1 demonstrated a good level of comprehension, while student #3 had the average level of comprehension. However, students' comprehension level decreased when 40-Watt lamp was used because the lamp was too bright and disturbed their focus and concentration.

Based on this study, learning process for getting higher level of comprehension depended on the light. The light effect was essential to help students understand what the teacher has articulated during the teaching and learning process as DHH students relied on reading the lip movements of the teacher [31].

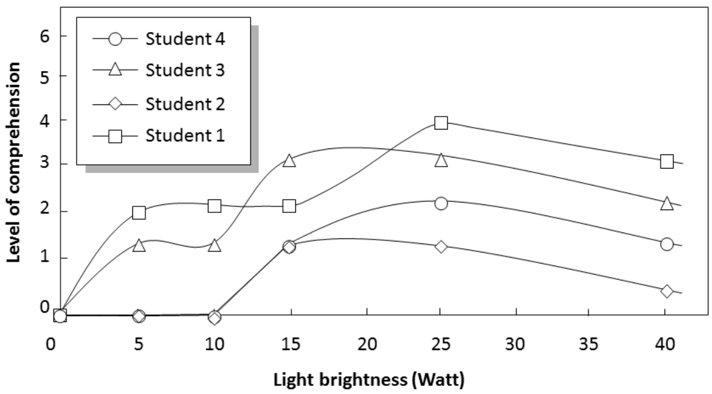

Fig. 4. The effect of light brightness towards Comprehension level in nanotechnology subject.

5. Conclusion

A way to teach a difficult subject to special needs students, particularly DHH students, has been presented. The results showed that difficult subject could be taught to DHH students although some previous studies limited the researchers to consider reading skills and the use of sign language in conducting the research. Thus, the initial process of the study was investigating the effect of IQ level of students towards students' comprehension on some subjects using the tests as suggested by previous researchers, in which the subjects were mathematics, social studies, science, Indonesian language, and religion. The results showed that IQ level did not significantly affected the level of students' comprehension towards the subjects. The surrounding factors, such as light brightness, are important and influencing the level of students' comprehension. To conclude, teaching difficult subjects, such as nanotechnology, to DHH students would be possible to be implemented if students' needs were addressed. However, the main key point is the way how to deliver the subject, and the combination of experimental demonstration can boost the level of students' understanding. In addition, that is true that nanotechnology improves science, technology, and knowledge, specifically in daily life. However, the present study focused on the finding a new strategy for teaching this new knowledge to the student with DHH. Thus, understanding on the possibility of DHH students to receive nanotechnology as a new knowledge quantitatively will be done in our future work. In addition, although the present method is successfully applied for DHH students, the implementation of the method conducted to the normal students must be further studied.

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