Journal of Engineering Science and Technology
Vol. 16, No. 3 (2021) 2245 - 2259

TEACHING HEAT TRANSFER ON SOLID-TO-LIQUID PHASE TRANSITION PHENOMENA TO STUDENTS WITH INTELLECTUAL DISABILITIES

RINA MARYANTI, ACHMAD HUFAD*,
ASEP BAYU DANI NANDIYANTO*, SUNARDI TUKIMIN

Universitas Pendidikan Indonesia,
Jl. Dr. Setiabudhi no 299, Bandung, 40154, Indonesia
*Corresponding Author: achmadhufad@upi.edu

Abstract

The purpose of this study was to demonstrate teaching heat transfer on the solid-to-liquid phase transition phenomena to students with intellectual disabilities. This study was conducted by combining conventional teaching method and experimental demonstration to three students with intellectual disabilities. Different from regular students, students with intellectual disabilities are rarely found in Indonesia since parents usually hide the condition of their children. As a model for solid-to-liquid phase transition material, we used ice cubes with various sizes to attract students' focus. The experimental demonstration was conducted by observing the melting of ice cubes under heat radiation from sunlight. The explanation was also completed by the interesting learning media. To analyse the successful teaching process, we also completed the study with pre-test/post-test, interview, and survey to students. The results showed that difficult subjects (such as heat transfer changing the form of solids to liquid) could be taught to students with intellectual disabilities. More than 67% of the topics can be understood by students. The main reason for the successful teaching process is due to using experimental demonstration in addition to the conventional teaching method. Other interesting occurrences are the methods and the learning media used that must be from a concrete and interesting teaching method. Otherwise, their focuses are easily disturbed.

Keywords: Heat transfer, Phase transition, Students with intellectual disabilities, Teaching.

1. Introduction

Heat transfer is a part of science learning taught in schools [1]. In the elementary school curriculum, students study heat transfer material in 5th grade. This material has a relationship with the material in the process of changing the form of a substance because the process of changing the form of a substance requires the influence of heat or heat, especially in changing the form of a solid to a liquid. Changing the form of a solid to a liquid, which is influenced by heat transfer, is very important to be taught to students because this material subject has many applicative benefits in daily life. In addition, this material becomes the basis of knowledge for students to understand further about science materials [1].

Currently, many studies discussed heat transfer [2], development of heat transfer learning media based [3], heat transfer characteristics [4, 5], and materials information for heat transfer [6]. In spite of many articles discussing on the process of learning science, we found rarely articles on learning science to children with special needs (students with intellectual disabilities) [7-9], especially for describing heat transfer for solid-to-liquid transformation.

In this study, we conducted research on teaching heat transfer on solid-to-liquid phase transition phenomena to students with intellectual disabilities. The originality of this research is the research subject, namely students with special needs and the learning methods used. We combined conventional teaching and experimental demonstration for teaching students with disabilities. We found that the experimental demonstration method made students to be more enthusiastic. In addition to the right method, instructional media is also an important aspect that must be considered. This is because students with intellectual disabilities need simple teaching as well as interesting and concrete media [7-9]. This study is also supported by our previous reports on teaching and experimentation in materials science [10, 11].

Therefore, the aimed of this study is to teach the process of teaching heat transfer on solid-to-liquid phase transition phenomena to students with intellectual disabilities. We used the pre-test and post-test method to evaluate students' abilities. In the learning process, we used conventional and experimental demonstration methods. We used ice cubes with various sizes to attract students' focus. The experimental demonstration was conducted by observing the melting of ice cubes under heat radiation from sunlight. The results showed that difficult subjects (such as heat transfer changing the form of solids to liquid) could be taught to students with intellectual disabilities. This study is suitable for covering issues in the differentiated instruction in science for students with special need, giving education and training.

2. Logical Framework

Figure 1 shows an illustration of the heat transfer process on an object. Students in regular schools are very easy to understand the concept of heat transfer process. They understand that there are three types of heat transfer: radiation, convection, and conduction [12].

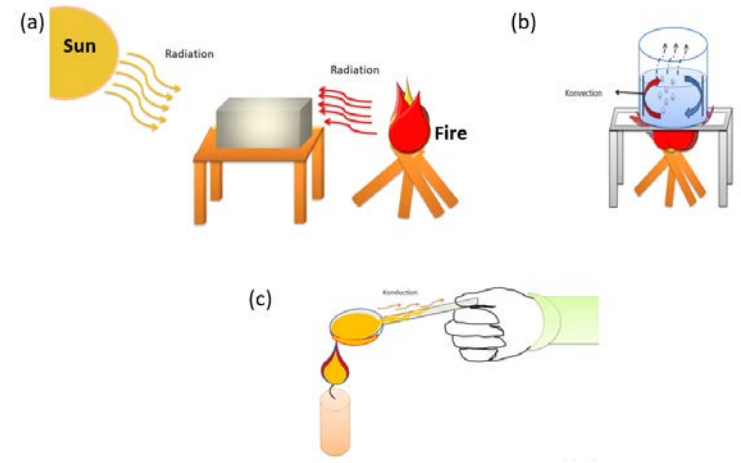

Fig. 1. Illustration of heat transfer
(a) radiation, (b) convection, and (c) conduction.

In short, as shown in Fig. 1(a), radiation is the process by which heat flows from high-temperature to low-temperature objects if the objects are separated in a space [13]. The term of radiation is commonly used in electro-magnetic waves. In the science of heat transfer, it is necessary to pay attention to matters caused by temperature, which can transport energy through a translucent medium or through space. For example, the melting of ice cubes on a table that are exposed to direct exposure to sunlight or bonfires describes the process of radiation. The legal basis for calculating the radiation is based on the formula of Stefan-Boltzmann [14] (see Eq. (1)):

$$q = \sigma . A . T^4 \tag{1}$$

where q is the heat transfer rate (W), σ is the Stefan constant (5.6703×10^{-8} W / m^2. K^4), A is the area of an object that emits radiation (m^2), and T is the absolute temperature (K).

The next heat transfer process is convection (see Fig. 1(b)). In the process of heat transfer in the phenomenon of convection, heat transfer media follows to move. Convection is the process of energy transport with the combined work of heat conduction, energy storage, and mixing movements. Convection is very important as a mechanism of energy move between the surface of solid, liquid, and gas objects. In heated water, a convection process occurs because the delivery medium (which is a water bubble) moves. The legal basis for calculating the formula used is in Eq. (2) [15]:

$$q = h\, A(T_w - T_\infty) \tag{2}$$

where h is the convection heat transfer coefficient (W/m^2. ºC), T_W is the wall temperature (ºC), and $T\infty$ is the fluid temperature (ºC).

The third heat transfer process is conduction (see Fig. 1(c)) where the process of heat transfer flows through the conducting medium from higher temperatures to lower temperatures. In general, conduction is the process by which heat flows from areas of higher temperature to regions of lower temperature in a medium (solid, liquid, gas) or between different mediums that come in direct contact. Conduction

is the only mechanism by which heat can flow in opaque solid. Conduction in a fluid depends on convection and radiation. The spoon, which is exposed to the heat of the fire in the candle, delivers heat to the end of the spoon that we hold. This is because the spoon is a medium of heat conduction. The legal basis for calculating the formula used is in Eq. (3) [16]:

$$q = -k.A\frac{dT}{dx} \tag{3}$$

where k is thermal conductivity (W/m. ºC), and $\frac{dT}{dX}$ is the temperature gradient.

The process of heat transfer is often found in daily life. The process of heat transfer also has an important role in the process of changing the form of substances. One of them changes in the form of solid to liquid which occurs in ice cubes when exposed to heat. In the process of changing the form from a solid into a liquid, an explanation of the effect of heat transfer on the process of changing the form of a solid into a liquid is more difficult to teach to students with intellectual disabilities. They need special treatment and methods to be able to understand the material being taught.

To make this type of students easily understand. Figure 2 is the illustration of the effect of heat transfer radiation on the process of changing the form of substances from solid to liquid. Ice cubes that are exposed to light radiation from the sun will melt. The legal basis for calculating depends on melting heat coefficient [17] (see Eq. (4)):

$$q = m.L \tag{4}$$

where m is the mass, and L is the heat melting coefficient.

Before we learn the process of calculating the heat received or released an object, we should understand about one principle in the discussion of the famous heat and the black energy principle. In mixing two objects with different temperatures, the high temperature releases heat. The heat released (Q_{free}) will be absorbed by an object with a low temperature (Q_{accept}) until finally the temperature of the two objects is the same. Briefly, the Black's principle states in the following Eq. (5)[18]:

$$Q_{free} = Q_{aaccept} \tag{5}$$

An important note to remember is that the principle of the Black principle only applies to isolated systems, meaning that there is no heat exchange with the environment. Changing the form of a solid into a liquid requires heat transfer or heat.

In this study, we showed and compared ice with different sizes (Fig. 2). Different from large ice (Fig. 2(a)), small cubes of ice have larger the surface area of the ice wider, causing the ice to melt quickly when exposed to heat (Fig. 2(b)). The surface area affects the heat transfer since the Q_{accept} is a function of surface area (as shown in the Eq. (1)). The derived equation can be written as in Eq. (6):

$$A = \frac{q}{aT^4} \tag{6}$$

Explanation of the difference in surface area that influences the process of accelerating the change in the form of solids into liquid due to the heat transfer event of radiation is very easily understood by children in general. However, children who experience intellectual disabilities need special learning, treatment, methods, and media.

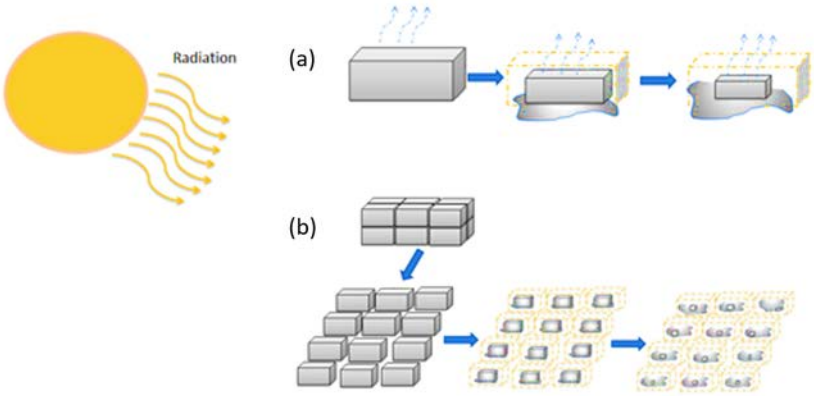

Fig. 2. The Illustration process of changing the form of a solid into a liquid due to the influence of heat transfer (radiation) by sun light. (a) is the illustration of melting ice for the larger ice (uncut frozen water), (b) is for the smaller ice (broken frozen water).

3. Hypothesis

Children with special needs are children who have obstacles both due to external and internal factors so that they have problems in the learning process in daily life. There are two categories of children with special needs, namely temporary and permanent [19]. Children with temporary special needs are children who have special needs due to external factors. Children with permanent special needs are children who have problems in the internal aspects of the child. These problems cause various problems in the learning process, so that they need special education and services [7]. One of them is in children with intellectual disabilities.

Children with intellectual disabilities are one of the children with special needs in the permanent category. They have problems with external and internal factors from within the child. The problem is the presence of dysfunction in the brain or intelligence of the child. Children with intellectual disabilities have intelligence characteristics below average, problems with adaptive behavior and occur during developmental times [7]. This resulted in problems in the learning process. One of them is that children have problems in academic, language, and concentration aspects [8]. Children have difficulties in understanding something that is complex and abstract, so children need concrete and simple learning. Limitedness of the teacher's knowledge about how to teach students with low IQ levels of students [20, 21]. In order to teach students with intellectual disabilities, the teacher must pay attention to several factors. Among them are learning methods and media. The experimental demonstration method is an effective way of teaching material about heat transfer to students. That is because with this method children can learn something concrete. In addition, the teaching used must be associated with habituation, so that the tools and materials used must be closely related to something that children often find it in daily life [10]. That is the main reason why reports on teaching difficult subjects, such as heat transfer in the process of changing the form of a substance to students with intellectual disabilities, are rarely found because researchers will face obstacles as students with have unique characteristics.

This hypothesis in the research is the use of the experimental demonstration. The method is considered effective enough to teach heat transfer to students because the delivery of simple material and concrete media makes it easy for students to understand it.

4. Research Method

4.1. Research subjects, population, and sample

This study used a single subject research (SSR) experimental approach with an A-B research design (pre-test and post-test), which focused more on limited research subjects (i.e., the subject of heat transfer in the process changes form of substances from solid to liquid). The study participants were three elementary students (11-12 years old) with intellectual disabilities in the elementary school for special education SLB B-C Dharma Wanita in Kuningan District, Indonesia. This school is only for students with special needs in this province in Indonesia. Students with intelligence barriers are not mixed with normal students in the teaching and learning process because research is conducted in extraordinary schools not in inclusive schools. Teaching is also delivered by combining conventional teaching and experimental demonstration method. Then, to improve student understanding, we completed teaching interesting media. This is because students with intellectual disabilities require a concrete and simple learning process.

In addition, to get basic information from students, such as IQ levels, demographic information, and their basic knowledge abilities specifically in subjects (Indonesian, social science, science, religion and mathematics), we conducted interviews with teachers in the school. The data collected was then used to develop research instruments. After that, to simplify the analysis of student ability levels, all information obtained was assessed using a scale score from 0 (cannot do anything), 1 (not good), 2 (good enough) 3 (good), 4 (very good).

4.2. Conditions of teaching, instrument, and procedures

Teaching was done in two sessions. Each teaching session was conducted in class or outside the classroom with duration of 60 minutes. The process of simplifying the teaching of the effect of heat transfer in the process change of solid into liquid substances, we provided information only about the heat transfer of process change of solid into liquid in daily life, namely: the effect of heat on changing the form of solids into liquid. We got information on students' understanding, through the teaching process, which was supplemented by pre-test and post-test, survey, and interviews.

The first session taught students about the importance of heat transfer in daily life, while the second session was an experimental demonstration of the process of changing the form of a solid into a liquid. The experimental demonstration was to provide an understanding of why solids of ice cubes melt when exposed to heat and ice cubes that have a wider surface (small, chopped ice) melt faster than non-cut ice cubes.

4.3. Experimental demonstration

The experimental demonstration was carried out in a baking pan (length = 18 cm, width = 8 cm, and height = 10 cm). We put in 400 mL of water to two baking pans with identical sizes and dimensions. Then, we put them into the freezer and waited until they were freezing. Frozen water in the baking pan was taken. We broke the

frozen water from both pans. One frozen water from one pan was used directly, whereas the other frozen water was broken until the sizes of about 2 cm. Then, we measured the ice and put into the other baking pan (width = 40 cm length, width = 35 cm, and height = 2 cm). Finally, the experiment was done by put the ice into the open place with sun light irradiation. To ensure that students understand the meaning of the heat transfer, we compared large and small ice in the same weight (Fig. 2).

Students observed the process of heat transfer radiation from exposure of sunlight. They evaluate the process of changing the form of substance (i.e., ice cubes) from solid to liquid. They also compared which ice cubes melt faster.

5. Results and Discussion

5.1. Student demographics

Figure 3 shows the demographic data of students with intellectual disabilities. There are seven information displayed from students aged 11 to 12 regarding the diagnosis of students with intellectual, motor skills, language, communication, concentration, independence, and interaction, academic. This information is very important to know because it illustrates the extent of the ability of IQ and student development, as a basis in carrying out the teaching process of teaching. Also, it will be needed for analysing the main reason for the successful teaching process. Students with intellectual disabilities have IQ levels of less than 70 which makes them have various obstacles in various learning and development processes.

Student 1 shows level 3 on motor skills, which means that students have good motor skills, students can do gross motor activities and fine motor activities. Aspects of language development are at level 1, because students' language development is not good in the aspects of pronunciation and articulation. Students are sometimes not clear enough to say and have limited vocabulary. The development of student communication is at level 2 which means that the communication skills of children are quite good in receiving information even though sometimes there must be repetition of instructions. Concentration, independence, social interaction and student emotions are also at level 2, which means it is quite good. From the explanation of parents, teachers and the results of student observations often do daily activities independently, besides that the interaction of students in school with their peers is quite good. But student 1 has poor academic ability, in reading aspects students are only able to recognize vowels and consonantal letters, although the motor aspects of students are good but new students are able to write to the stage of copying and student writing is not neat. In the numeracy aspect, new students are able to recognize numbers 1 to 10 and count concrete objects 1 to 5.

Student 2 shows level 2 in motor skills, which means that the motor skills of students are quite good, students can do gross motor activities and fine motor skills quite well. Aspects of language development students are at level 3, children have quite a lot of vocabulary and students often talk. In the development of communication students are at level 2 which means the ability to receive and convey information is quite good child. Concentration, independence, social, and academic interaction of students are also quite good. Parents, teachers, and observations explain that students often do their daily activities independently; besides, student interactions at school with their peers are quite good. In the aspect

of reading, students are able to memorize letters and write through personal dictation. In the aspect of writing, children are able to copy with neat writing and in the aspect of counting children are able to recognize numbers 1 to 10, counting concrete objects 1 to 7 and addition under 5. However, student 2 has poor emotional abilities, when his friend is directing the children to get angry.

Student 3 shows level 2 in motor skills, which means students' motor skills are quite good, level 1 in aspects of language and communication, which means children's language abilities are not good in receiving and conveying information, students tend to be quiet and passive. Concentration, independence, social interaction, academic and emotional children are not good. Students are more often dependent on their mothers in carrying out daily activities and students also often carry out activities as they wish regardless of the commands of their parents or others. Besides, students often judge their friends.

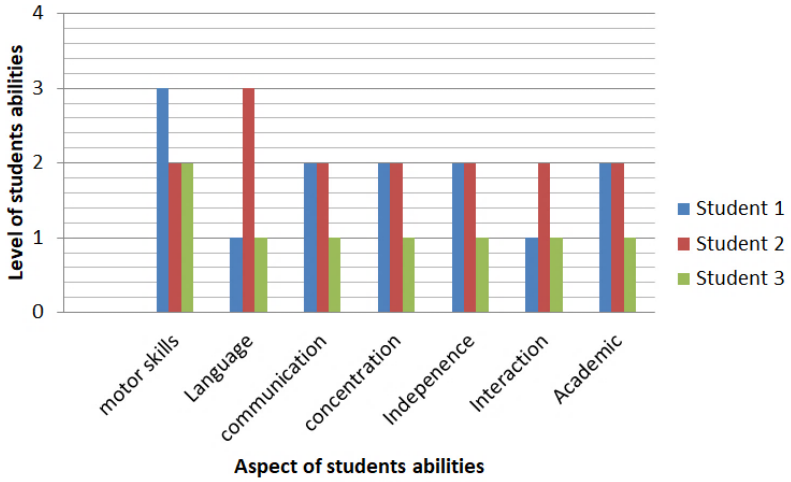

Fig. 3. Data about student conditions.

Figure 4 shows the level of understanding of children in the subject of learning at some subjects taught. There were five subjects observed, namely Indonesian language, social science, science, Islamic religion and mathematics. This information is very important in knowing students' readiness to conduct experiments. Student 1 has an understanding of Indonesian language subjects at level 2, meaning that in learning Indonesian language student 1 can follow fairly well. Student 2 at level 3, and student 3 at level 1, mean that student 2 can follow the learning well while student 1 is less able to follow Indonesian language learning is not good. Language acquisition is related to students' cognitive level [22]. Student 1, student 2, and student 3 also have problems with abstract and symbolic concepts, which are the basis for learning mathematics [23]. Children with intellectual disabilities require a concrete learning process that is simple and fun. Student 1, student 2, and student 3 have a poor understanding of science. However, students 1 and students 3 like religious subjects, they are always enthusiastic when following religious learning.

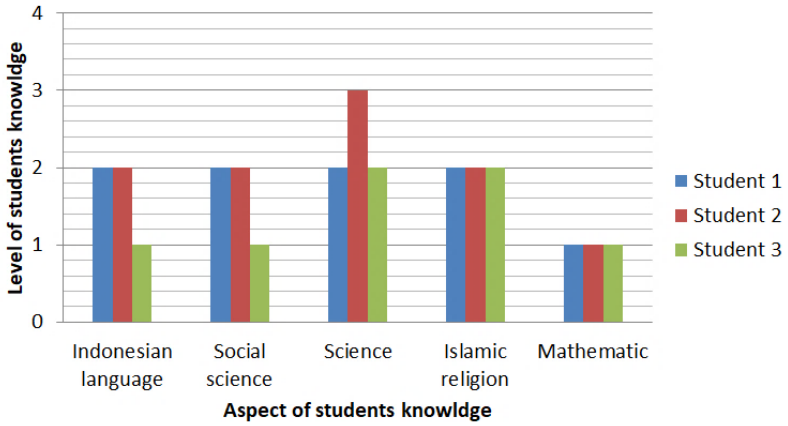

Fig. 4. Student knowledge levels in subjects.

5.2. The phenomenon of learning heat transfer on changes in substance

Students have new experiences in demonstrating the heat transfer for changing the material form from a solid into a liquid. Students observe the change of ice cubes into water. When ice cubes are exposed to sunlight, the process of change the substance from solid to liquid occurs is due to the influence of heat transfer (radiation), in which this is explained in the Eq. (1) [24].

Figure 2 shows the illustration process of changing the form of a solid into a liquid due to the influence of heat transfer (radiation) by sun light. We made two experiments with compare process of changing cube from sizes. Fig. 2(a) is the illustration of melting ice for the larger ice (uncut frozen water). Fig. 2(b) is for the smaller ice (broken frozen water).

We explained to students that for the process of change the shape of ice cubes into liquid requires heat or heat. The sun acts as the source of heat energy. We also explained to students that the greater the surface area of an object, the greater the rate of heat transfer. This is evidenced by the fact that children observing the changes (that occur in ice cubes in the same size and cut into smaller pieces (Fig. 2(b)) is faster than melting ice cubes (Fig. 2(a)). Students understood that changing the form requires heat transfer or heat [25]. Students also understood that ice cubes that were cut into smaller pieces make the surface area of the ice wider and cause the ice to melt quickly when exposed to heat, in which this is in line with Eq. (6).

5.3. Teaching process and analysis date

Based on student demographic data, IQ and basic knowledge of students, we find the complexity of student with intellectual disabilities. Students have difficulty understanding an abstract concept. Student learning must use concrete and applicable objects. Thus, we limit the application of heat transfer to in the process changes form of substances in daily life as the main subjects. Experimental demonstration methods can be done to improve the success of learning in the classroom [26]. The experimental demonstration method is one of the methods that lead to learning objectives [27]. The aim is to give students an understanding of the

basic concepts of the effect of heat transfer on the change in the form of substances from solid to liquid.

The results showed that difficult subject regarding heat transfer can be taught to students with intellectual disabilities. Because students with intellectual disabilities have low IQ levels compared to other normal students, teachers must be skilled in teaching science technology themes related to daily activities so that students' level of understanding increases [9]. Special techniques for teaching are also needed because the concentration of students with intellectual disabilities to learn something is limited and easily distracted. They cannot absorb effectively using the conventional teaching and learning process. Media and methods are needed that interest children to learn [7].

After teaching the subject of heat transfer in the process change form of substances, we found:

a. In the initial session of the first 30 minutes, because teaching was delivered using the lecture method, students did not seem interested. The level of student understanding is low and questioned.
b. A simple experimental demonstration was added in the last 30 minutes of the first session and attracted students' attention. Indeed, this increases student interest. Specifically, when pouring water with a measuring cup on the baking pan. The students also tried to put water in the pan in the refrigerator.
c. A simple additional experimental demonstration helped by learning media increases the level of student understanding, compared to conventional teaching with the lecture method only. Children begun to understand the learning material being taught.
d. The results showed that the learning methods and media used greatly influenced the level of motivation and understanding of students.

From the results above, the teaching process for students with intellectual disabilities requires special techniques. Specifically, teachers need to provide interesting methods to attract students' concentration and focus. Otherwise, the level of student understanding cannot be predicted. To ensure students' level of understanding during the teaching process, a final test on the heat transfer of changes in the form of substances is given to students with intellectual disabilities constraints from elementary to intermediate level questions.

Table 1 shows some questions related to heat transfer given to students. For evaluation, we asked seven questions. To confirm the impact of additional experimental demonstrations on increasing student understanding, we compared the results of the teaching process with (w) and without (w/o) additional experimental demonstrations. To clarify the analysis, Table 1 shows the results of pretest and posttest in each session.

Student 1 did not understand heat transfer. After being taught through the experimental demonstration, students became more understand in the heat transfer process. When students were asked again in the second session, students were able to answer most questions correctly and were able to get a total score of 18 or 64% of the maximum score of 28. Student looks enthusiastic when conducting experiments. Student focused and gave more attention to the stages by stages of heat transfer experiments conducted.

Table 1. Questions about the demonstration of the heat transfer experimental changes in the form of substances.

No	Question	Student 1		Student 2		Student 3	
		W0	**W**	**W0**	**W**	**W0**	**W**
1	Will the cooled water freeze?	0	2	0	3	0	1
2	Are ice cubes a solid object?	1	3	1	3	0	2
3	Will the hot ice cubes melt?	0	2	0	3	0	2
4	Is sunlight a source of heat energy?	0	3	0	3	0	2
5	What causes ice cubes to melt?	0	3	0	3	0	2
6	Does the ice cubes cut into smaller pieces will melt faster if exposed to heat?	0	3	0	3	0	2
7	Do you know the relationship between the surface area of new ice and the melting process of ice cubes that are exposed to heat?	0	2	0	3	0	1

Student 2 previously did not understand heat transfer. Student was silent and answered incorrectly. However, after being taught through the experimental demonstration method students became better. In the second session, students were able to answer most questions correctly and were able to get a score of 21 or 75% of the maximum score of 28.

Student 3 also did not understand about the heat transfer. Student was passive. After being taught through the experimental demonstration method, student understood. However, this student is not as good as students 1 and 2. Student 3 obtained a total score of 12 or 42.85% of the maximum score of 28.

Most students after learning by using the experimental demonstration method can understand the effect of heat transfer on changes in the appearance of substances. Two out of three students or 67% have an answer score of more than 60% of the maximum score.

Figure 5 shows the pre-test and post-test data. KKM is the minimum completeness criteria or minimum value that must be obtained by students. The learning process is said to be successful when more than 50% of students score above the KKM (students get a score of 17 or more than 60%). All students scored below the KKM before using the experimental demonstration method, but after using the experimental demonstration method more than 50% of students scored above the KKM.

All students showed improvement in understanding the learning process. As shown in Table 1, 67% of students have increased understanding. In the learning process, the first session of students 1, 2, and 3 were given seven questions. Most questions cannot be answered by students 1, 2, and 3. Students' answers were careless. The questions were repeated four times to ensure that they are understand the main topic that were asked.

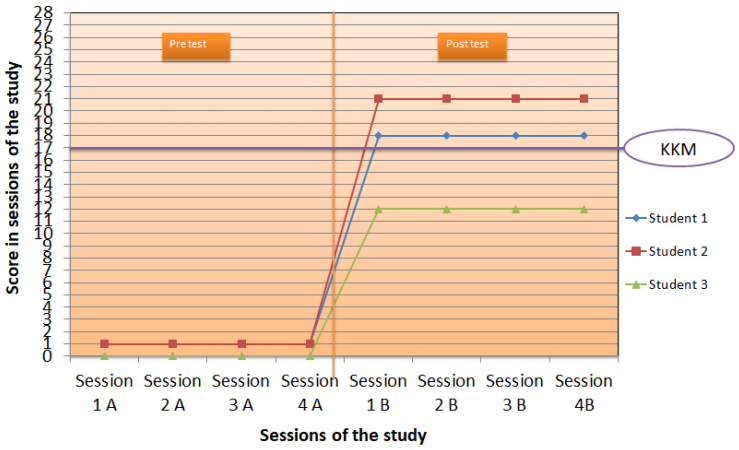

Fig. 5. The results of the pretest-posttest assessment of students.

Students 1 and 2 know only about ice cubes as solid objects. Student 1 answered "yes ma'am, solid ice cube" with a hesitant attitude and pronunciation that is not too clear. This is different from student 2 who had quite clear pronunciation and a loud voice. Student 3 tent to be passive and did not want to answer. This is because students 3 were more interested in bullying students 1 and 2 by taking their stationery. After that, students were invited by the teacher to do a simple experiment demonstration. Students were invited to leave the classroom, students looked enthusiastic when pouring water into the ice pan and put it into the refrigerator.

Each student takes 400 mL of water with a measuring cup and put it in ice. Student 2 is able to know the water dose of 400 mL. In contrast to student 1 who takes less than 400 mL, student 3 took more than 400 mL. Student 3 spilled water while pouring water into the ice, it was because student 3 always made joked. Students inserted a baking dish with water into the freezer and they took rest while waiting for the next session.

In session 2, after learning in class the child was brought to the school field. Ice cubes from the refrigerator were taken and heated in the field by the sun. Students conducted experimental demonstrations and observed the process of heat transfer that occurs in the process of changing the form of solids into liquid. Students were asked to compare which ice cubes melt faster. Students had more understanding since they know the sun is a source of heat energy. Indeed, they understood a process of radiation and the concept of the shape of objects. Student 3 found difficulties when determining the relationship of ice surface area with the melting process. Students only took smile when we asked.

In session 2, students were given the same seven questions as questions in session 1 with four repetition rates. All students showed increases in understanding of the heat transfer experiment. Although the level of understanding of students 3 is still below 50% the maximum score. That is because the student 3 has poor concentration and academic ability.

Based that above analysis, we found that explaining subject using conventional teaching method is not effective. Students are easily distracted. However, making and adding experimental demonstration improved well students' comprehension.

Especially, it is needed in the heat transfer learning process for students with special needs. Although most people consider heat transfer material difficult to learn the students with intellectual disabilities, but the experimental method the student's ability increases. This is because the learning method is attractive, simple, and concrete which makes it easier for students to understand the learning material. Similar to our previous study [8, 9, 11, 24, 28], experimental demonstration is effective to attract student focus. Students are more easily managed, and their comprehension is improved.

In addition, we have a limitation where the number of subjects is three students. We took the subject of three students because parents of students with intellectual disabilities rarely send their children to school, so we have difficulty-finding subjects for children with intellectual disabilities who attend class in 5th grade. Further, this is worsened by the condition of COVID-19 pandemic, in which most of the classes are done in online [29-34]. Indeed, in the further research, we will add the people subject the research.

6. Conclusions

The results of this study point out those difficult subjects (such as heat transfer of changing solids into liquid) can be taught to students with intellectual disabilities. The learning methods and media used is very important and must be made as concrete and interesting as possible according to the child's needs. Students with intellectual disabilities found it difficult to understand abstract learning concepts. Experimental demonstration has shown the way for increasing the students' understanding on difficult subject.

Acknowledgements

RM acknowledged Sekolah Pasca Sarjana Universitas Pendidikan Indonesia. We also thanked to teacher of Sekolah Luar Biasa in Kuningan, Indonesia for assisting this experiment. This study was supported by Bangdos Universitas Pendidikan Indonesia and Penelitian Unggulan Perguruan Tinggi (PTUPT) from RISTEK BRIN.

References

1. Nandiyanto, A.B.D.; Raziqi, G.Y.; Dallyono, R.; and Sumardi, K. (2020). Experimental demonstration for enhancing vocational students' comprehension on heat transfer through conduction and radiation of light bulb. *Journal of Technical Education and Training*, 12(3), 189-195.
2. Abdurrahman, A.; Umam, R.; Irzaman, I.; Palupi, E. K.; Syazali, M.; Junaidi, R.; and Adi, L. C. (2019). Optimization and interpretation of heat distribution in sterilization room using convection pipe. *Indonesian Journal of Science & Technology*, 4(2), 204-219.
3. Wijayanti, A.; and Sukamto. (2017). Development of heat transfer learning media based on android application inventor (AI) to instill student self directed learning. *Journal of Innovative Science Education*, 6(2), 205-211.
4. Putra, Z. A. (2017). Improving heat exchanger network design of a revamped chemical plant. *Indonesian Journal of Science and Technology*, 2(1), 87-96.
5. Yang, L.; and Du, K. (2017). A comprehensive review on heat transfer characteristics of TiO2 nanofluids. *International Journal of Heat and Mass Transfer*, 108(Part A), 11-31.

6. Ju, S.; and Shiomi, J. (2019). Materials informatics for heat transfer: recent progresses and perspectives. *Nanoscale and Microscale Thermophysical Engineering*, 23(2), 157-172.
7. Maryanti, R.; Hufad, A.; Sunardi.; Nandiyanto, A.B.D.; and Al-Obaidi, A.S.M. (2020). Understanding Covid-19 particle contagion through aerosol droplets for students with special needs. *Journal of Engineering Science and Technology*, 15(3), 1909-1920.
8. Maryanti, R.; Hufad, A.; Sunardi.; Nandiyanto, A.B.D.; and Manullang, T.I.B. (2020). Understanding coronavirus (COVID-19) as a small particle to students with special needs, *Journal of Humanities and Social Sciences Research*, 2(1), 121-130.
9. Maryanti, R.; Nandiyanto, A.B.D.; Hufad, A.; and Sunardi, S. (2021). Science education for students with special needs in Indonesia: From definition, systematic review, education system, to curriculum. *Indonesian Journal of Community and Special Needs Education*. 1(1), 1-8.
10. Hidayat, D.S.; Rahmat, C.; Fattah, N.; Rochyadi, E.; Nandiyanto, A.B.D.; and Maryanti, R. (2020). Understanding Archimedes law : What the best teaching strategies for vocational high school students with hearing impairment. *Journal of Technical Education and Training*, 12(1), 229-237.
11. Nandiyanto, A.B.D.; Asyahidda, F.N.; Danuwijaya, A.A.; Abdullah, A.G.; Amelia, N.; Hudha, M.N.; and Aziz, M. (2018). Teaching "nanotechnology" for elementary students with deaf and hard of hearing. *Journal of Engineering Science and Technology*, 13(5), 1352-1363.
12. Sheikholeslami, M.; Hayat, T.; and Alsaedi, A. (2016). MHD free convection of Al_2O_3-water nanofluid considering thermal radiation: a numerical study. *International Journal of Heat and Mass Transfer*, 96, 513-524.
13. Aklis, N. (2006). Studi heat losses pada isobaric zone reaktor HYL III direct reduction plant Pt. Krakatau steel. *Majalah Teknik Mesin*, 7(2), 64-69.
14. Giddings, S.B. (2016). Hawking radiation, the Stefan–Boltzmann law, and unitarization. *Physics Letters B*, 754, 39-42.
15. Li, Z.; Wang, Z.; Liu, T.; Zhao, L.; Sun, T.; and Grattan, K.T.V. (2018). High-sensitivity "hot-wire"-based gas velocity sensor for safe monitoring in mining applications. *IEEE Sensors Journal*, 18(24), 10192-10198.
16. Hrma, P.; Pokorny, R.; Lee, S.; and Kruger, A.A. (2019). Heat transfer from glass melt to cold cap: melting rate correlation equation. *International Journal of Applied Glass Science*, 10(2), 143-150.
17. Hayat, T.; Imtiaz, M.; and Alsaedi, A. (2016). Melting heat transfer in the MHD flow of Cu–water nanofluid with viscous dissipation and Joule heating. *Advanced Powder Technology*, 27(4), 1301-1308.
18. Feng, Z.; Cai, Y.; Yan, G.; Hu, Z.; Dang, K.; Zhang, Y.; Lu, Z.; Cheng, H.; Lian, X.; Xu, Y.; Zhang, C.; Feng, Q.; Zhou, H.; Zhang, J.; and Hao, Y. (2019). A 800 V β-Ga_2O_3 metal–oxide–semiconductor field-effect transistor with high-power figure of merit of over 86.3 MW cm^{-2}. *Physica Status Solidi (a)*, 216(20), 1-6.
19. Soendari, T.; Abdurahman, M.; and Mahmud, M. (2008). *Pengajaran Asesmen Anak Berkebutuhan Khusus*. Bandung, Universitas Pendidikan Indonesia.
20. Handayani, D.; Hufad, A.; Tukimin, S.; Rochyadi, E.; and Nandiyanto, A.B.D. (2020). Teaching PH of suspension containing colloidal particles suspension

to students with deaf and hard hearing. *Journal of Engineering Science and Technology*, Special Issue, 48-57.

21. Reich, C.; Hambleton, D.; and Houldin, B.K. (1977). The integration of hearing impaired children in regular classrooms. *American Annals of the Deaf*, 122(6), 534-543.
22. Sukirman, S. (2012). Hubungan antara perkembangan kognitif anak dan pemerolehan bahasa (tinjauan pembelajaran bahasa). *Ulul Albab: Media Aktualisasi Fikir dan Zikir*, 14(1), 76-93.
23. Wulandari, S.; and Prasetyaningrum, S. (2018). Media stamp game untuk meningkatkan kemampuan berhitung anak slow learner di sekolah dasar. *Psympathic: Jurnal Ilmiah Psikologi*, 5(2), 131-148.
24. Pezeshki, Z.; Soleimani, A.; Darabi, A.; and Mazinani, S.M. (2018).Thermal transport in: building materials. *Construction and Building Materials*, 181, 238-252.
25. Scruggs, T.E.; and Mastropieri, M.A. (1995). Science and students with mental retardation: an analysis of curriculum features and learner characteristics. *Science Education*, 79(3), 251-271.
26. Rofian. (2017). Penerapan metode pembelajaran demostrasi pada pendidikan seni rupa di sekolah dasar. *Majalah Ilmiah Pendidikan Dasar*, 6(2), 173-181.
27. Prayogi, S.; Yuanita, L.; and Wasis. (2018). Critical inquiry based learning: A model of learning to promote critical thinking among prospective teachers of physic. *Journal of Turkish Science Education*, 15(1), 43-56.
28. Maryanti, R. (2021). Assessment of mathematical abilities of students with intellectual disabilities during the COVID-19 pandemic. *Indonesian Journal of Community and Special Needs Education*. 1(2), 47-52.
29. Mulyanti, B.; Purnama, W.; and Pawinanto, R. E. (2020). Distance learning in vocational high schools during the covid-19 pandemic in West Java province, Indonesia. *Indonesian Journal of Science and Technology*, 5(2), 271-282.
30. Nasution, A.R.; and Nandiyanto, A.B.D. (2021). Utilization of the google meet and quiziz applications in the assistance and strengthening process of online learning during the COVID-19 pandemic. *Indonesian Journal of Educational Research and Technology*, 1(1), 31-34
31. Huwaidi, F.; Nandiyanto, A.B.D.; and Muhammad, N. (2021). The urgency of online learning media during the covid-19 pandemic at the vocational school in Indonesia. *Indonesian Journal of Educational Research and Technology*, 1(2), 35-40
32. Bermudez, T. C.; Alcaide, A. M.; Barcelona, A. M.; Peralta, E.; and Malaco, A. (2021). Online class: Its implication towards academic skills development. *Indonesian Journal of Educational Research and Technology*, 1(2), 61-66
33. Ganesha, P.; Nandiyanto, A.B.D.; and Razon, B.C. (2021). Application of online learning during the covid-19 pandemic through zoom meeting at karya mekar elementary school. *Indonesian Journal of Teaching in Science*, 1(1), 1-8.
34. Ramdhani, T.; Nandiyanto, A.B.D. (2021). The use of Whatsapp social media as reinforcement online learning during the COVID-19 pandemic, *Indonesian Journal of Multidisciplinary Research*, *1*(1), 107-112.