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# Teaching Viscosity to Students with Special Needs in Vocational High Schools from Daily Products: From Literature Review on Concept, Misconception, to Teaching and Learning Process

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***Abstract*— Students with special needs are students who have barriers in their developmental and academic aspects. They need a learning media that meets their needs. This study aimed to demonstrate the strategies in teaching using the experimental demonstration to students with special needs and to identify misconceptions during the teaching and learning process. To support our teaching strategies, an experimental demonstration (recorded by video as the learning media) was used. This study used an experimental method (single subject research) with A-B (Pre-test and Post-test) research design for students with special needs (i.e., intellectual disabilities and hearing impairment), and the results of teaching students with special needs were compared to that of teaching general vocational high school students. The experimental activity was done to get the viscosity level of eight substances (i.e., syrup, cooking oil, hand soap, liquid detergent, floor cleaner liquid, condensed milk, and mineral water). Condensed milk has the highest viscosity, and mineral water is the lowest. The result of this study showed that a combination of experimental demonstration and video is effective for improving the understanding of students with special needs, confirmed by the increasing pre and post-test results and supported by interviews. In addition, the identification data of the misconception test showed a decrease in misconceptions after carrying out the learning process using video. The use of interesting media with simple explanations made it easier for students with special needs to understand the material being taught.**

***Keywords*— Education; experimental video-based learning media; students with special needs; viscosity; vocational high school.**

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## I. INTRODUCTION

The learning process affects students learning outcomes. Several factors affect student learning outcomes, including learning motivation, teaching methods, and learning media resources [1]. The effective method and learning media enable students to understand the learning materials being studied. Thus, teachers need to consider the appropriate learning method and the media to accommodate students' diverse needs, especially when they learn science.

Learning science promotes knowledge development and student capacity. Learning science is important in vocational schools because it develops students' knowledge and competencies [2]. Vocational school relates to practicum [3], [4]. That is why the vocational high school has different curriculum types (compared to general high school) that relate to industrial needs [4], [5]. Vocational high school is also known as Sekolah Menengah Kejuruan (SMK) in Indonesia and it has science topics in its curriculum [6]. One of the science topics that the students need to master is viscosity.

In short, the concept of viscosity is often referred to as the thickness of fluid [7]. The greater viscosity of the fluid resulted in the more difficult the fluid to flow and the more difficult objects to move in the fluid [8]. In liquid substances, viscosity results in cohesion forces between liquid molecules. If the object has a spherical shape and falls into a fluid, the velocity increases as the earth's gravity reaches a fixed maximum speed (terminal velocity). Fig. 1 shows the terminal velocity of an object (marble) that is dropped into a thick fluid (honey). When the marble reaches the liquid honey, it will flow down due to the weight of the object W and the gravity of the surface. The marble experiences the frictional force of the *Fa* and the resistance of the *Fs* to the viscosity of the honey liquid. The coefficient of friction is referred to as viscosity.

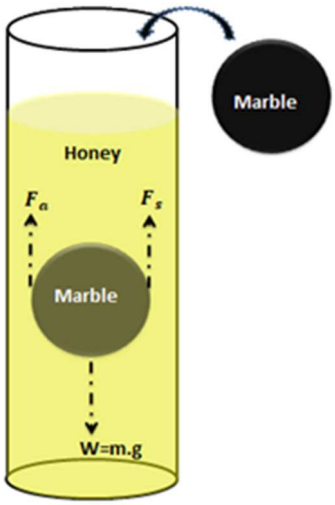


Fig. 1 Illustration of terminal velocity on honey when a marble is dropped

The frictional force of the surface of a solid body moving with fluid is proportional to the relative velocity of the object moving to the fluid. The flow barriers within the fluid are caused by friction between the fluid component attached to the surface of the object and the fluid portion next to it. The frictional force is proportional to the fluid viscosity coefficient ($\eta$). A falling marble experiment conducts the calculation of η using Stokes law. The marble drops in a liquid-filled glass vessel where the viscosity coefficient is calculated. The faster marble speed correlates to the lower results in viscosity value. The density of marble resembles more friction, and marble decreases at a constant speed ($v$), so the equation (1) is applied:

$$W = F_s \qquad (1)$$

$$m \times g = 6\pi r \eta V$$

where $Fs$ is the resistance force (N), $\eta$ is the coefficient of viscosity (kg $m^{-1}$ $s^{-1}$), $r$ is the radius of the ball (m), π is 22/7, and $v$ is the relative rate of objects in the fluid. The law of Stokes formula $Fs$ can be derived into equation (2):

$$F_s = 6\pi r \eta V \qquad (2)$$

Several factors can affect viscosity [14]:

- Pressure. The higher fluid pressure resulted in the liquid's greater viscosity.
- Temperature. The viscosity decreases when the temperature rises.
- Size and molecular weight. The viscosity increases as the molecular weight rises, and viscosity will increase if there are more double bonds.
- Intermolecular strength. A greater bond between the molecules of liquid results in a higher viscosity value.

Solution concentration: Viscosity experiences a straight ratio with the concentration of the solution. A solution with a high concentration would also have a high viscosity, as the concentration shows the number of particles of matter dissolved for each unit of volume.

Viscosity is a measure that determines the thickness of a fluid or liquid [7]. Vocational students must study viscosity to get information and understand the knowledge of making oil, syrup, and other products that require thickness analysis. Knowing viscosity will improve students' skills because vocational students' alumni in Indonesia generally must be innovative and productive. Additionally, students at vocational high schools must have the skills to produce goods with high economic value [4].

The viscosity learning process needs experimental activities to understand the thickness level of fluids. Besides, learning requires support from technological development [9]. As technology advances in education, teachers can utilize video and smartphone applications as learning media to make the learning process run effectively and enable students to understand viscosity easily.

Many papers have discussed teaching viscosity[10], measurement of viscosity of organic particles [11], analysis of viscosity [12], and measurement of microemulsion viscosity and its implications for chemically enhanced oil recovery [13]. However, research discussing viscosity learning for students with special needs (SSN) in vocational schools is relatively difficult to find. Although some papers reported the teaching viscosity of SSN [7], they were limited to the way of teaching since they focused more on the science concept rather than education. Further, no studies discuss the misconception during teaching viscosity.

SSNs are children with developmental and academic difficulties that need special education and services. SSNs have various barriers in the learning process [9]. SSNs find it difficult to understand complex and abstract information and need simple explanations and concrete media. Concrete and engaging media also make SSNs more enthusiastic in the learning process and make it accessible for SSNs to grasp the content being studied.

Based on our previous studies [6], [7], [9], [14]-[21] regarding strategies in teaching science and technology to students, this study aimed to identify viscosity learning for vocational students in West Java, Indonesia. Specifically, this study focused on demonstrating the strategies in teaching viscosity using the experimental demonstration of SSN and identifying misconceptions during the teaching and learning process. This study also assessed the results and compared them to the general student (SV) to get excellent strategies for teaching SSN.

Several liquid materials were utilized, such as syrup, cooking oil, liquid hand soap, dishwashing liquid detergent, floor cleaner liquid, concentrate liquid detergent, condensed milk, and mineral water, because students often use those materials in their daily life. Daily products give some advantages, such as being harmless and easily found. Indeed, students are familiar with the products and have opportunities to do it repetitively at home. Thus, students can understand the viscosity level of materials they often see and use. Marbles and pearl brooch were employed as experimental tools because they were easily observed when they were put into the liquid materials during the viscosity test. Pearl brooch and marbles were not significantly different in weight and size. The experimental demonstrations were conducted and recorded with the video. Then, the video was distributed to students to support the teaching and learning process. This experimental video can be used to support the teaching and learning process [3], [19], [22], especially for SSNs. We

believe this research can make the learning process more effective for SSNs.

In a COVID-19 pandemic situation, students were unable to have face-to-face experiments with the teacher, making teachers must put in additional strategies for enhancing students' comprehension [15], [16], [18]-[20], [23]-[25]. In normal conditions, SSNs learn together at school with SV. However, due to the COVID-19 pandemic outbreak, while learning viscosity requires effective learning methods to accommodate the requirements of SSN, the learning process was conducted using experimental demonstrates supported by video media. This study found that this online learning type is an effective problem solver during this pandemic condition. Indeed, this type of teaching process can be used and support distance learning

### *A. Teaching and Learning of SSN*

Teaching methods for SSN generally include communication, task analysis, direct instruction, prompts, and cooperative learning. The teaching method must be adapted to the needs of SSN [9]. Educators in a school must give more attention and support. Thus, SSNs have the enthusiasm to achieve optimal development. SSNs are students with sensory organ disorders, physical disorders, mental retardation, speech and language disorders, learning disorders, and emotional and behavioral disorders. These various limitations and inabilities lead to problems in the learning process[9]. The education given to SSNs is the same as that given to normal students. SSNs are children with internal or external problems, so they impact the emergence of problems in the learning process. In general, explanations to understand SSNs with intellectual disabilities and hearing impairments are as follows[9]:

- Students with intellectual disabilities are SSNs who have intelligence levels below the average (<70). They have adaptive behavior problems that occur in their developmental age. Internal problem factors in students are because they have neurological dysfunction problems, resulting in a lower mental developmental age than the calendar age. Students with intellectual disabilities have characteristics of having difficulties in understanding information, memorizing, having weak concentration, and easily forgetting quickly. The characteristics of barriers that students with intelligence barriers have an impact on the emergence of problems in the learning process. They have difficulties in understanding complex and abstract concepts.
- Students with hearing impairment are SSNs who have problems with the aspect of hearing[21]. They have internal problem factors, namely problems with organs and hearing nerves, making them difficult to communicate and understand information verbally[26]. Students with hearing impairment have the characteristics of having difficulties in understanding abstract and complex information[27]. They are students who learn by utilizing the visual senses or visual learning[9]. Most of the information is obtained through the sense of sight [14]. They have different levels of hearing problems. Students can use hearing aids if their hearing problems are low, and they can still be assisted by these devices [26], [28]-[30]. Students with hearing impairments have the same level of intelligence as SV [27]. However, the characteristics of the problems result in most of them having low knowledge and learning outcomes.

Several factors need to be considered for teaching and learning SSN, namely:

- Understanding each SSN as a unique individual.
- Learning orientation starts with students (student center learning);
- Active, cooperative, creative, and effective learning.
- Providing diverse learning experiences;
- Adding specific teaching techniques.

A proper teaching method is needed for the learning process at school to run smoothly and optimally. A good teaching method is a teaching method that is applied to the right problems and conditions for students [9]. This means that it is applied to the learning problems of each SSN with certain characteristics. Generally, in the process of teaching and learning activities, some methods can be used. There are also more specific teaching methods according to the characteristics of SSN. Several learning theories are commonly used by educators at school, including cognitive, behavioristic, humanistic, and constructive.

- The cognitive theory describes learning as an internal activity consisting of several processes, such as understanding, remembering, processing information, problem-solving, analysis, prediction, and feelings [31]. This learning theory is described as a computer. The initial process begins with data input, then processes it to get the final result. In the learning process at school, an example of the application of this theory is that teacher uses language that students easily understand, and the teacher provides space for them to talk to each other and discuss the topics between students.
- The behavioristic theory describes an experience that can change a person's behavior (habits or thought processes) due to the learning process from experience itself. This theory is known as the teacher-centered learning process. Teachers are required to be more creative in delivering learning material. Some of the processes of applying this theory are that the teacher encourages students. Thus, students can feel curiosity. Teaching must provide stimuli to get student responses, reinforce students, and make repetition to do stimuli in different forms in students.
- The humanistic theory describes that learning methods focus on learners to develop their potential [32]. The humanist theory is supported by two factors: the cognitive role of one's understanding of science and the effective role of mental factors that shape the individual.
- The constructive theory describes a method to invite students to explore knowledge freely. Also, students can interpret the learning subjects according to their experience. In its implementation, students are given space to make ideas and come up with the ideas using their language[33]. The hope is that through familiar explanations, other people are expected to be able to accept the ideas presented and stimulate their imaginations.

The above learning theory were used for this study's teaching and learning process. Indeed, it can only be

implemented through effective teaching strategies. One of the solutions in the additional teaching techniques is using media. Instructional media plays an important role in the success of the teaching and learning process since it can increase the students' learning outcomes and achieve learning objectives. Media that is concrete, interesting, and according to students' requirements is needed in their learning process. Students are easier to understand the material through the method of habituation, assignment, direct practice, simplicity, and fun. Technology is also needed to assist student learning [30]. However, there seems to be a distortion of meaning and function. Some teachers and educators feel that learning media must be luxurious, up-to-date, and related to IT [34]. Learning media are all the means, tools, and media used in the learning process. Indeed, there are many other definitions, but it seems they point to the level of understanding. There are various kinds of purposes for using learning media. Everything can be different depending on the perspective, classroom conditions, teacher conditions, materials, topics, and teaching techniques used. The objectives of the learning media include[35]:

- Helping the teacher deliver the material
- Helping students to understand better the topic being studied.
- Making learning more effective.
- Making learning more alive with interactive learning media.
- Make learning more meaningful.

Several classifications of instructional media are based on function, form, and level of complexity. There are several kinds of learning media, including[36] (i) Print Shaped, (ii) Learning Media in the form of Audio, (iii) Learning Media in the Form of Audio-Visual, and (iv) Learning Media Shaped Realia / Object Learning Media Based on Digital Applications.

Several basic principles related to the use of instructional media in the teaching and learning process that should not be forgotten are (i) Effectiveness, (ii) Means of Student Motivation, (iii) Price, (iv) Level of Complexity, (v) Master's Mastery Level, (vi) Learning model, (vii) Examples of Learning Media, (viii) Poster, (ix) Flashcards, and (x) Decal

One of the learning media used is video[19,22,37], which can generate the focus of students in the form of audio and visual. Learning using video makes students understand the material being taught. For students with hearing impairments, the delivery of information through the visual senses is the most effective strategy[9].

### *B. Misconception*

Misconceptions can be described when the wrong understanding of an idea and an event that is built is based on one's experiences[38]. Misconceptions are a loss of concept understanding received by students from a teacher or a teacher not following experts' concepts. The misconceptions experienced by students must be understood and discovered by teachers to help students get the correct concepts. Identification of misconceptions is crucial to finding the location of the missing link in the teaching process and its cause. If misconceptions are allowed to continue, it can greatly impact the students' learning outcomes and further the students' learning processes. It is necessary to hold a diagnostic test to identify student misconceptions so they can be found and resolved effectively. Indeed, it will improve student learning outcomes, and students do not experience misconceptions and problems when working in the future. Several factors influence the misconception, including students, teachers, textbooks, context, and teaching methods. Various misconceptions that students often carry out will result in problem-solving errors. Thus, misconceptions that students often do should not remain too long because they will affect their understanding of the concepts in other material subjects. Identifying misconceptions include the Certainty of Response Index (CRI) and diagnostic tests. One of the latest developments in the diagnostic test is the four-tier diagnostic test, which is a diagnostic test with four levels. This four-tier diagnostic test can be said to be a combination of multiple-choice tests with open reasoning and CRI because the level of the diagnostic test is accompanied by a level of confidence [38]. Detailed information for the CRI analysis is in the literature[38].

## II. Materials and Methods

In short, the experiment was done using the following steps: (i) planning, (ii) providing tools and materials, (iii) conducting viscosity measurement experiments, (iv) making of experimental video, (v) implementing learning, (vi) evaluating data, and (vii) analyzing data.

At the initial stage (planning), field studies were conducted to find subjects and determine problems. The next stage is to prepare the tools and materials for conducting experiments on the viscosity of the material. After that, experiments were conducted by measuring the viscosity level of a substance. As the media to support the learning process, learning videos were made from the experimental stages carried out. Then, the learning process was carried out in two learning sessions. The first session used only the conventional method, and the second applied experimental activity with videos. In the first session, the learning evaluation was completed by asking questions about the material that was taught and related to misconceptions. The results of the first evaluation were called the student pre-test data. The activity was carried out to determine the level of students' understanding of the material being taught and how high the level of misconceptions occurring in students. The evaluation stage in the second session was carried out to determine the level of understanding and effectiveness of the learning process as well as changes in the level of misconceptions occurring in students. This test was called the post-test. The final stage of this research is to process and analyze research data by comparing pre and post-test data of students as well as the level of misconceptions occurring in students. The analysis was also completed by comparing the results of SSN and SV taking vocational schools. To understand the level of misconception, this study used CRI.

### *A. Material for Teaching*

We used chemicals: syrup (Marjan Cocopandan, PT. Lasallefood, Indonesia), cooking oil (Kunci Mas, PT. Smart Tbk, Indonesia), liquid hand soap (Nosy, PT. Sparindo Mustika, Indonesia), dishwashing liquid detergent (Mama Lemon, PT.Wings Surya, Indonesia), floor cleaner liquid (SoKlin Lantai, PT. Wings Surya, Indonesia), concentrate liquid detergent (SoKlin Liquid, PT.Wings Surya, Indonesia),

condensed milk (Frisian Flag, PT. Frisian Flag, Indonesia), and mineral water (Le Minerale, PT. Tirta Fresindo Jaya, Indonesia) and measure the thickness level. Materials are a 100-mL capacity measuring cup (pyrex, PT. Iwaki Glass, Indonesia), marble with a diameter of 1 cm (Indonesia), pearl brooch with 0.75 cm in diameter (Indonesia), 210-mL capacity plastic glass (Indonesia), and stopwatch (PT Samsung, Indonesia).

A viscometer (Zahn cup- #2 ASTMD 4142, China) and ElcoCalc were utilized to measure the viscosity level. To measure viscosity from Zahn cup, formula, or ElcoCalc application. The calculation formula is in equation (3):

$$K(t - C) = V \tag{3}$$

where $K$ and $C$ are the constant and the concentration given in the Zahn Cup table, respectively. $K$ is the constant (3.50 for Zahn Cup #2), C is the constant (14 for Zahn Cup #2), $t$ is the flow time in seconds, and $V$ is the kinematic viscosity in centistokes (cSt). When using the ElcoCal application for Zahn Cup calculation, viscosity results can be easily obtained. By entering the decantation time, the viscosity level in the kinematic viscosity in centistokes (cSt) is easily obtained.

### *B. Experimental Demonstration*

The liquid was put in a 100-mL-chemical measuring tube. Then, a marble with a diameter of 1 cm was placed into the chemical measuring tube containing 100 mL of liquid. The time the marble took to reach the bottom surface of the chemical measuring tube was measured using the mobile stopwatch. Besides marble, a pearl brooch with a 0.75-cm diameter was used and applied using the same procedures.

To calculate the viscosity, liquid (120 mL) was put into a plastic glass (210 mL). Then, the Zahn Cup was put into a plastic cup (that contains the liquid). The liquid must enter the Zahn Cup. The Zhan Cup was then left in the plastic cup for about 1 minute. It had the aim that when the Zahn cup was lifted, the flow can be observed visually. After that, we lifted the Zahn cup and calculated the time needed until the flow stopped dripping from the Zahn cup hole.

The learning video was made based on the stages aforementioned. The video was also completed with explanations of the viscosity theory. The video was distributed to support the teaching and learning process.

### *C. Research Subject*

This study used an experimental method (single subject research) and A-B (Pre-test and Post-Test) design for two types of students. Group 1 is 10 SV and group 2 is three SSNs (i.e. students with intellectual disabilities and students with hearing impairment) at Vocational School in West Java, Indonesia.

### *D. Teaching Method*

Learning processing steps are the planning, implementation, observation, and evaluation/reflection stages (See Fig. 2). The activity is divided into two sessions.

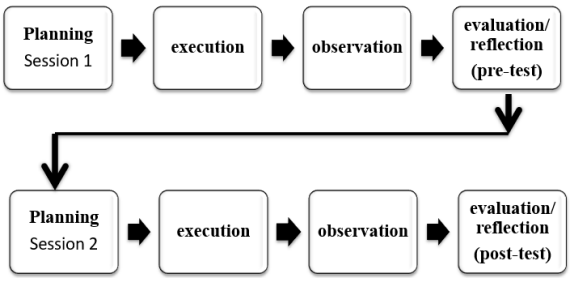


Fig. 2 Learning scenario

The planning stage's first session includes activities to determine student profiles and viscosity. The implementation stage was carried out through the learning process through the lecture method without using experimental videos. Observations were made to determine students' attitudes during the learning process. The final stage of learning was carried out by observing the students' abilities and the level of misconceptions that occur. The results of this evaluation become the pre-test scores before entering the second session.

In the second session, the planning stage includes activities to understand student profiles and determine material about viscosity, provision of tools and materials, experimental activities, and making videos. In the implementation stage, the learning process was carried out by implementing experimental videos to help deliver learning materials. Observations were made on how students' attitudes in following the learning process. The evaluation stage is carried out to determine students' abilities and student misconceptions in understanding the material being taught, the evaluation stage is carried out at the end of the learning process by asking several questions.

Two methods carried out the teaching method. The teacher conducted experimental activities and makes them in the video. This was done in such a way that SSN can easily understand the material provided by the teacher. In the first session, the teacher delivered the material through lectures only and an evaluation (pretest) was given in the first session after the teacher explained the material about viscosity through lectures without using any media. In the second session, the learning process was supported by experimental demonstration with videos. Students listened to the video which is almost 7 minutes long. After that, the evaluation (post-test) was carried out by asking the same 30 questions as we did during the pre-test. The pre and post-test were conducted to find out the data on the level of students' knowledge and misconceptions that occurred.

### *E. Teaching Instruments*

Interviews were conducted with the class teachers to get information about students' abilities (e.g., their intelligence level, concentration, communication, and their motoric skills, as well as data about students' knowledge academically (Indonesian Language, Mathematics, Natural Sciences, and Civics Education subjects) to develop research instruments. All the information was assessed using a score of 5 on a scale of 0 (do not know anything), 1 (not good), 2 (less good) 3 (good enough), 4 (good), 5 (very good).

Pre-test and post-test (30 questions) were given to students by asking a few questions to assess the effect of the use of experimental video on the level of understanding of SSN in

learning the viscosity of the fluids. We put scores: 0 for no and 1 for yes. If students answered yes to all the questions, then the total score would be 100. Question-making is based on the analysis of curriculum material in vocational schools.

Table 1 shows 30 questions related to the level of viscosity of substances given to students. The results of the teaching process with experimental video (W) and without (W0) experimental video media were compared. Each question has a maximum score of 1. If the students answer 30 questions correctly, the maximum score obtained is 100. The correct answers were then calculated using equation (3):

$$\text{Score} = \frac{score\ obtained\ by\ student}{3} \text{ x } 10 \qquad (3)$$

Pre- and post-test were used to evaluate the understanding of SSN in studying the viscosity of liquids. We also assessed multiple-choice questions to determine the misconceptions that occur in students understanding of the teaching material on viscosity. To find out the level of misconceptions that occur in students, we used an instrument by inserting several questions in each of the 30 questions given. After the choice of answers to the questions, we asked the question, "How sure are you in answering the questions?". Students were given answer choices 0, 1, 2, 3, 4, and 5, and each answer had its description. Table 2 shows the instruments used to measure the level of misconceptions that occur in students. If students filled the answer choosing answers of 0, 1, or 2, the student's confidence level is classified as low. The level of student confidence is classified as high if students selected the answers of 3, 4, or 5.

## III. Results and Discussion

### A. Students Demographics

This study used a test for two types of students: SV and SSN. For SV, they had the ability of an average level of intelligence and did not have obstacles in the aspect of development. In contrast to SSNs who had barriers in various aspects of development, these problems are caused by the characteristics of problems possessed by SSNs which have an impact on both developmental and academic aspects[6].

The level of students' abilities in developmental areas, namely the level of intelligence, concentration, communication, and motor skills (See Fig. 3). All SV in a vocational school had good levels of intelligence, concentration, communication, and motor skills. Student A is a 21-year-old student with intellectual disabilities, and their intelligence level was level 1 or not good. The student's concentration and communication were at level 2 since the student was easily distracted and found it difficult to understand and convey information. However, student A has quite good motor skills. Student B is a 17-year-old student with hearing loss. Student B had a fairly good level of intelligence and motor skills (level 3). Student B had good concentration, but student communication was not good. That is because student B is a student with hearing impairments. Student B had limitations in understanding and conveying information verbally. He also had difficulty understanding complex language. They optimize the sense of sight to understand information. They are visual learners. In the learning process, visual media is needed to make it easier for student B to understand information[7]. Student C is an 18-year-old student with intellectual disabilities and did not have a good intelligence, concentration, and communication level. However, this student has fairly good motor skills. Students with intellectual disabilities have special characteristics that make it difficult to understand abstract information, repeated explanations, or habituations. Thus, they need concrete and interesting media. They required simple learning since they have below-average levels of intelligence[21].

Data regarding knowledge in each subject were analyzed. This had the intent and purpose of knowing the extent of students' knowledge level and interest in science learning. The activity of analyzing or assessing the level of students' abilities is crucial for determining effective learning programs and activities for students[9].

The level of student knowledge in academic aspects such as the Indonesian language, mathematics, natural sciences, and civic education (See Fig. 4). All SV had a good level of student knowledge in academic aspects. Students A and C did not have good academic abilities in the Indonesian language, mathematics, natural sciences, and civic education. Based on the information given by the teacher, the students with intellectual disabilities had low concentration, and their intelligence level is below the average level, which affected the learning outcomes. Student B had a fairly good level of academic ability in the Indonesian language, mathematics, natural sciences, and civic education. Students with hearing impairments did not have problems in the intelligence aspect although they had communication problems, which made them difficult to understand the information given during the learning process.

### B. Learning Process

Learning viscosity allows students to know the viscosity level of the fluids, especially for SSN. Viscosity is resistance to fluid flow, which is friction between liquid molecules [52]. Thus, a liquid with low viscosity will flow easily, while a liquid with a high viscosity will be difficult to flow. Detailed information for the viscosity experimental results is explained in our previous report [7].

The viscosity of mineral water will be different from that of syrup. Mineral water has a lower viscosity than syrup. Consequently, the object in the syrup requires more time to reach the bottom surface. The greater level of viscosity results in the greater frictional force produced.

The viscosity level of the liquid could be measured in several ways. The procedure for determining the viscosity of a material is to use a tool called a viscometer. Many forms of viscometers are used, including[7].

- Capillary/Ostwald viscometer. It works based on the time interval required for a certain amount of solution to flow through the capillary tube by the force caused by the weight of the solution itself.
- Hoppler Viscometer. It has functioned the same as any other viscometer, but it has a different way of working. Stokes' law is applied to the Hoppler viscometer to measure the viscosity of a liquid. Stokes' law itself means that the viscosity of a liquid is known by the way an object is dropped on the liquid. The object used to help measure viscosity on the Hoppler viscometer must be an object of definite size. In addition, the Hoppler

viscometer needs to consider the presence of friction and gravitational forces.

- Viscometer Cup and Bob. In this viscometer, how to measure viscosity is done by entering the liquid to be measured in a certain space. This space is located between the inner wall of the bowl (cup) and the outer wall (bob). After entering the liquid, the next step is to install the rotor. Finally, turn on the tool, and the viscosity value will immediately appear on the scale.

TABLE I
SCORE AVERAGE AND QUESTION ABOUT THE VISCOSITY OF SUBSTANCES GIVEN TO SSN AND SV

| No | Question | Average SSN | | Average SV | | Misconceptions on each item (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | W0 | W | W0 | W | SSN (Pre-test) | SSN (post-test) | SV (Pre-test) | SV (post-test) |
| 1 | Definition of liquid | 100 | 100 | 100 | 100 | 66.66 | 33.33 | 50 | 20 |
| 2 | Molecules in a liquid | 66.66 | 100 | 90 | 100 | 100 | 33.33 | 80 | 30 |
| 3 | Definition of fluid | 66.66 | 100 | 80 | 100 | 100 | 33.33 | 70 | 30 |
| 4 | Syrup is a liquid | 100 | 100 | 100 | 100 | 66.66 | 33.33 | 60 | 30 |
| 5 | Cooking oil is a liquid | 100 | 100 | 100 | 100 | 66.66 | 33.33 | 60 | 30 |
| 6 | Hand soap is a liquid | 100 | 100 | 90 | 100 | 66.66 | 33.33 | 70 | 40 |
| 7 | Dishwashing detergent is a liquid | 66.66 | 100 | 90 | 100 | 100 | 33.33 | 60 | 20 |
| 8 | Floor cleaner detergent is a liquid | 66.66 | 100 | 90 | 100 | 100 | 33.33 | 80 | 20 |
| 9 | Concentrated detergent is a liquid | 66.66 | 100 | 80 | 100 | 100 | 33.33 | 80 | 20 |
| 10 | Condensed milk is a liquid | 100 | 100 | 90 | 100 | 66.66 | 33.33 | 80 | 30 |
| 11 | Mineral water is a liquid | 100 | 100 | 100 | 100 | 66.66 | 33.33 | 60 | 20 |
| 12 | Syrup is thicker than water | 66.66 | 100 | 100 | 90 | 100 | 33.33 | 50 | 20 |
| 13 | Syrup is thinner than condensed milk | 100 | 100 | 100 | 100 | 66.66 | 33.33 | 40 | 20 |
| 14 | Water is thinner than the dishwashing liquid detergent and the floor cleaner liquid | 66.66 | 100 | 100 | 100 | 100 | 33.33 | 50 | 20 |
| 15 | Condensed milk is thicker than oil | 66.66 | 100 | 100 | 100 | 100 | 33.33 | 50 | 20 |
| 16 | Cooking oil is thinner than hand soap | 100 | 66.66 | 100 | 100 | 66.66 | 33.33 | 50 | 20 |
| 17 | Definition of viscosity | 0 | 100 | 40 | 100 | 66.66 | 33.33 | 80 | 30 |
| 18 | Understanding factors affecting viscosity | 0 | 66.66 | 30 | 90 | 66.66 | 33.33 | 70 | 30 |
| 19 | The size, shape, interaction of molecules, and temperature affect the viscosity | 0 | 66.66 | 40 | 90 | 66.66 | 33.33 | 60 | 50 |
| 20 | If a liquid flows easily, it has a low viscosity | 0 | 100 | 30 | 100 | 66.66 | 33.33 | 60 | 30 |
| 21 | If a liquid flows slowly, it has high viscosity | 0 | 66.66 | 30 | 90 | 66.66 | 33.33 | 70 | 40 |
| 22 | The formula for calculating viscosity | 0 | 66.66 | 30 | 80 | 66.66 | 33.33 | 50 | 40 |
| 23 | The objects that are dropped into 100 mL of condensed milk will reach the bottom of the surface slower than the object dropped into 100 mL of mineral water | 33.33 | 100 | 80 | 100 | 100 | 33.33 | 70 | 30 |
| 24 | Objects put into 100 mL of condensed milk need more time to get to the bottom of the surface than objects that are put into 100 ml of mineral water | 33.33 | 100 | 80 | 100 | 100 | 66.66 | 60 | 30 |
| 25 | If an object takes more time to reach the bottom of the surface, it has a high viscosity | 33.33 | 66.66 | 40 | 90 | 100 | 66.66 | 40 | 50 |
| 26 | If an object takes less time to reach the bottom of the surface, it has a low viscosity | 33.33 | 66.66 | 40 | 100 | 100 | 33.33 | 60 | 40 |
| 27 | If an object reaches the bottom of the surface slower, it has a high viscosity | 33.33 | 66.66 | 30 | 100 | 100 | 66.66 | 80 | 40 |
| 28 | If an object reaches the bottom of the surface quicker, it has low viscosity | 0 | 33.33 | 50 | 90 | 100 | 66.66 | 80 | 50 |
| 29 | The benefits of studying viscosity | 0 | 66.66 | 40 | 100 | 100 | 33.33 | 60 | 20 |
| 30 | Viscosity is useful for determining the viscosity of oil, soap, paint, and the production of other liquid industrial materials | 0 | 66.66 | 50 | 100 | 100 | 33.33 | 70 | 30 |
| | Total | 1499.3 | 2599.3 | 2120 | 2920 | 2532.40 | 1132.20 | 1900 | 900 |
| | Score % | 49.98 | 86.64 | 70.67 | 97.33 | 84.41 | 37.74 | 63.33 | 30 |

*Note: W0 = conventional teaching (without experimental video), and W = experimental video

TABLE III
INSTRUMENTS FOR MISCONCEPTION

| Question | How sure is your level of confidence in answering the questions? | | | | | |
|---|---|---|---|---|---|---|
| **Answer Options** | **0** | **1** | **2** | **3** | **4** | **5** |
| Criteria Description | 100% guessing | 75 - 99% guessing | 50 - 74% guessing | 24 - 50% guessing | 1-24% guessing | No guessing (0% guessing) |

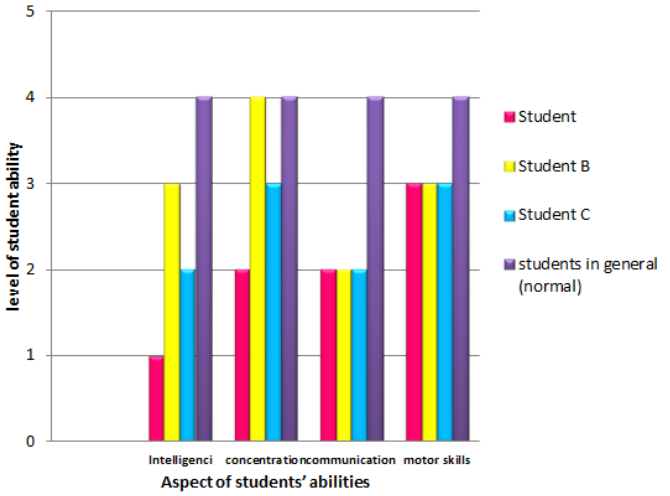


Fig. 3 Students' conditions

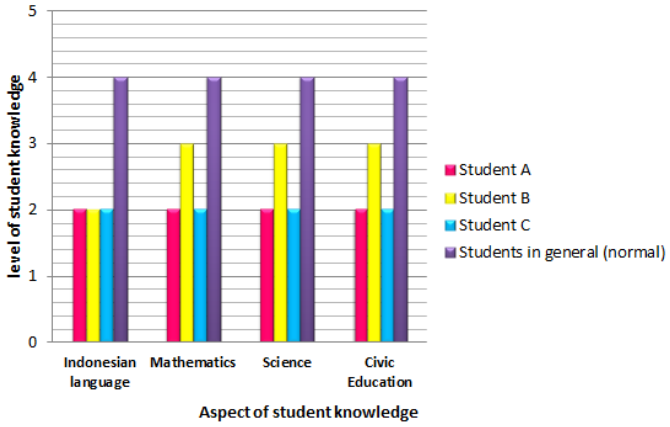


Fig. 4 Aspect knowledge of students' understanding levels

- Cone and Plate Viscometer. It is a more sophisticated viscometer because it can measure the thickness of the liquid in detail. This viscometer can measure the liquid with a small volume. The measurement results from the cone and plate viscometer have high accuracy.
- Zahn Cup. It is a simple tool for checking the viscosity of a liquid or measuring the viscosity of a liquid, having a shape like a small bowl (cup) made of stainless with 2 long handles attached to the side. The small bowl has a small hole in the center and a capacity of 43 mL. It is used to compare viscosity between specimens based on the flow time in seconds. The viscosity of a liquid is expressed in terms of the "flow time (in seconds)" required for a given volume of liquid immersed in the cup to flow out through the hole. Several types are available: Zahn Cup # 2, #3, #4, and #5.
- ElcoCal. ElcoCal is an android application/software that has a function to calculate the viscosity level. This application converts the flow time from the measurement results using the Zahn Cup to Centistokes (cSt). ElcoCalc instantly converts the cup viscosity flow time in seconds to Centistokes (cSt). The trick is to simply select the Zahn Cup type, enter the flow time, and ElcoCalc will calculate the change in time from seconds to Centistokes (cSt).

In this study, we tested the time required for an object when putting it into a liquid. In short, the longer the time taken for objects to reach the surface, the higher the viscosity or thickness of the liquid, and the faster the time taken for objects to reach the surface, the lower the viscosity or thickness of the liquid.

The viscosity learning process was conducted for 90 minutes and divided into two sessions (each session lasted 45 minutes). The steps in each activity session include planning, implementation, observation, and evaluation or reflection stages. In the first session, viscosity learning was carried out without experimental videos, and the material was delivered orally. At the end of the first session, evaluation activities were completed by giving 30 questions to determine the level of students' understanding. The evaluation data in the first session was made as to the student pre-test data. In the second session in the implementation stage, a learning process was carried out using experimental video media to deliver material about viscosity. At the end of the learning activity in the evaluation stage, 30 questions were given to students as post-test data. Learning using experimental video media affects student learning outcomes. This can be seen in the average value. The average learning outcomes obtained by students have increased. In the first session, before doing experimental video media, student learning outcomes (pre-test) were below 75. In the second session, after using experimental videos, student learning outcomes were above 75 (Table 1). Methods and media in accordance with student needs make teaching easier for students to understand the learning material

### *C. Analysis Data*

The comparison of misconceptions between SSN and SV was analyzed. Misconceptions are important to be understood. Thus, problems in the teaching process do not occur again in the next learning process. SSNs have characteristics that cause them to experience problems in the learning process. These problems also have an impact on the occurrence of higher misconceptions compared to SV. SV also experienced misconceptions although the level of misconceptions that occurred was lower than students with special adherents. Although SV does not have obstacles such as SSN, it does not require the possibility of them experiencing misconceptions in learning. This is due to many factors that influence students in understanding the material presented, both from the aspects of concentration, health, and the condition of students while participating in the learning process [9].

Table 1 shows the analysis of misconceptions for each item. In the pretest and post-test activities, SSN had a greater percentage of misconceptions than SV, namely 84.41 and 37.74%, respectively. Students generally had an average

value of misconceptions in the pretest and post-test, namely 63.33 and 30%, respectively. Fig. 5 shows the pre-test and post-test scores obtained by students. Student A got 26.7 on the pre-test and 76.7 on the post-test. Student B got 60 on the pre-test and 90 on the post-test. Student C got 63.3 on the pre-test and 93.3 on the post-test. Learning science, in the context of viscosity, is considered difficult. However, it can be taught to SSNs in vocational schools.

On the other hand, some factors need to be considered before starting the class such as learning methods the learning media and tools, and materials must also be adapted based on students' needs[17]. This study found that the use of methods and media affects reducing misconceptions. Although SSN experiences greater misconceptions than SV, the differentiation is not so high. Based on the results of the study, it can be suggested that using the experimental video as learning media is effective when learning viscosity for SSN. SSNs require effective and attractive learning media in line with their needs. Video use had a positive effect on increasing student knowledge[7]. This can be seen from the post-test scores.

Each of the students got a score above 70. Student B was enthusiastic during the learning because students with hearing impairment had visual learning characteristics. Students with hearing impairments easily received information through the visual senses [17]. Students A and C were also enthusiastic about seeing the experimental videos during learning. Thus, interesting learning videos, simple explanations, and materials used in daily life help students with intellectual disabilities to easily understand viscosity. This is proven that students with intellectual disabilities need simple explanations and concrete media in the learning process [7]. In learning, students with intellectual disabilities' age do not affect the level of their understanding. This could be seen in student A. Despite having an older age than student C, student A had a lower grade than student C. Even though students A and C are both children with intellectual disabilities, each student has different potential.

In addition to comparing the value of student learning outcomes, SSN requires special treatment compared to SV. The results showed that misconceptions were occurring in the learning process. Although the average score for the misconception of SV was lower than that of SSN, additional treatment must be considered. If misconceptions are allowed, it will cause learning problems in the next material. But this study found that using attractive media with simple explanations (as we discussed using experimental demonstration with video) effectively reduces the misconception, informing that difficult material subjects can be delivered and understood easier for SSN.

### *D. Contribution Video Media in Studying the Viscosity*

It is important to teach viscosity material because it is in the curriculum. Also, vocational school students study viscosity material as an initial knowledge for learning more complex material. Thus, studying viscosity has many advantages; one of which is as a provision for students when entering the workforce. Thus, the selection of learning media used is very important when studying viscosity material. Experimental demonstration with video media facilitates students in understanding the material of the viscosity being studied, especially for SSN. SSN needs some support from the media to make them easily understandable. Indeed, the video is effective for distance learning [19], and it is good for being implemented for the teaching and learning process during the COVID-19 pandemic condition since it can be done using online learning [25,39].

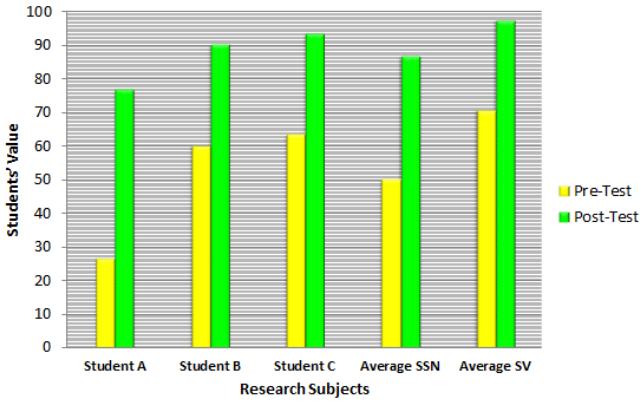


Fig. 5 The data of pre-test and post-test scores obtained by students

### *E. A Conceptual outline of the research*

This research has a concept of how to find out an effective learning process for students with special needs in viscosity material. In addition, the assessment of misconceptions is also analyzed to determine the comparison between students with special needs and students in general. In concept, the viscosity of matter is closely related to phenomena that often occur in everyday life. This is one of the reasons the viscosity material is very important to be taught to students [7]. To make it easier for students with special needs to understand the material being taught, products in everyday life are used as a tool and material for making learning media. Students can easily understand something through habituation, concrete objects, and interest [40].

In the implementation process, we conducted a viscosity test using tools and everyday product materials and used experimental demonstration methods to make learning videos. This activity is carried out to make it easier to convey information to students. Students with special needs need concrete, interesting, simple media and easy to understand [40]. Especially for students with intellectual disabilities and students with hearing impairments. The use of learning videos from the demonstration results of the viscosity test experiment makes it easier for students to understand the information conveyed. This is because video media attracts students' attention, especially for students with hearing impairments, making it easier for students to understand the material presented. After all, they are visual learners [9].

The learning process in the first session was carried out using the lecture method. The initial activity was carried out by apperception, the core activity was carried out by delivering viscosity material through lectures, and the closing activity was carried out by evaluation (pretest). During the activation process, we observed by conducting observation activities. This is done to compare the level of effectiveness using the experimental demonstration method equipped with instructional video media in the second session. Pretest and post-test evaluations were carried out at the end of the learning session to determine the level of students'

understanding of the material being taught. The results showed that students had a higher level of understanding of the viscosity material after being taught using the experimental demonstration method, which was equipped with learning video media in the second session. During the learning process in the second session, students were more active and enthusiastic in participating in learning. This is because the methods and media adapted to students' needs make it easier for students to understand information [6].

This research was important because it could be an alternative for teachers in teaching students with special needs, especially in viscosity material. This is because most teachers who did not have special education expertise had difficulties teaching students with special needs [41]. The results of this study were expected to be new knowledge for teachers that science learning, considered difficult to teach for students with special needs, can be easily taught to students. One of the keys to success is that the materials, methods, and learning media must follow students' needs.

## IV. Conclusion

Effective strategies in teaching using experimental demonstrations supported by video were demonstrated with the analysis of misconceptions. The learning process begins with the preparation of tools and materials, experimental activities and making videos, implementing videos in the learning process, and evaluating. The results showed an increase in student knowledge. The use of methods and media affects reducing misconceptions. Although SSN experiences greater misconceptions than SV, the differentiation is not so high. The use of attractive media with simple explanations (as we discussed using experimental demonstration with video) is effective, making difficult material subjects' deliverable and understood easier for SSN.

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