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Distance Learning Innovation in Teaching Chemistry in Vocational School Using the Concept of Isotherm Adsorption of Carbon Microparticles

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Abstract: The purpose of this study was to demonstrate distance learning innovation in teaching chemistry in vocational school using the concept of isotherm adsorption of carbon microparticles. The subjects were 60 vocational school students in Bandung, Indonesia, who took a 15-question pre-test and post-test with a learning video for supporting distance learning process. The subjects were focused to understand the successful teaching process, which were divided into the control class and the experimental class. The control class was done by giving a video containing conventional teaching process (without experimental demonstration), while the experimental class was done by giving a video containing experimental demonstration. To support the teaching process, the experimental video was chosen as the suitable teaching medium, including the production of carbon microparticles, adsorption measurement, data analysis, and an explanation of the adsorption mechanism. The results showed increases in the post-test scores compared to the pre-test. The t critical two-tailed value was 2.04, which was higher than the t statistic value (-2.52), ensuring the successful teaching for improving the students' understanding on carbon adsorption phenomena. The learning video was provided visual and audio experiences. Video learning media gave positive impacts to students' understanding, which was prospective for distance learning process. However, additional experimental demonstration inside the video learning media enhanced student's interest in particular subjects and motivated them to learn more about the teaching subject, in which this become new innovation in the distance learning process. This study demonstrated the importance of combination between experimental demonstration and video as a teaching media for improving students' comprehension, which can be implemented during special condition, for example COVID-19 pandemic.

Keywords: Adsorption Isotherm, Teaching, Experimental Demonstration Video

1. Introduction

Learning at the Vocational School is full of practicum. Vocational students must do practicum from simple to complex experiments (Rosina et al., 2021; Rahmadhani et al., 2021). In practicum usually, students fully carry out experimental activities. However, during special conditions such as the COVID-19 pandemic, practicum cannot be conducted directly since students are not permitted to attend school. Regulations were made so that the learning process was carried out online

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(Anggraeni et al., 2020; Mulyanti, Purnama, & Pawinanto, 2020). Teachers should come up with effective techniques for helping students comprehend the subject, particularly tough subjects that should be practised through the practicum. Several methods of online learning have been reported, such as an asynchronous learning method (Daniel, 2020), an online learning platform "google classroom" (Okmawati, 2020), a synchronous method using Learning Management System (LMS) (Hoq, 2020), distance teaching model learning (Flores & Marilia, 2020) online teaching platforms (such as Email, WhatsApp, Telegram, Skype, Google Meet, Youtube, Zoom, Instagram, Facebook, and Twitter) (Mishra, Gupta, & Shree, 2020; Saripudin et al., 2020), an e-module application and video demonstration.

One of the best methods to deliver practicum is an experimental demonstration (Hidayat et al., 2020). However, during the COVID-19 pandemic, this cannot be done (Sangsawang, 2020). Indeed, this brings great impacts to the teaching and learning process, as well as students' understanding (Andhini & Sakti, 2021). Thus, an additional method is important to support the distance learning process. Experimental demonstration with videos can deliver experiment-related matter. Video can provide a real picture of how the experiment is carried out, including the work steps and how the results are obtained. Many experimental demonstration videos have been done to convey abstract matter during distance learning. For example, experimental demonstration videos are used to teach the effect of flour variations on the mechanical strength of crackers (Anggraeni et al., 2020), teach making briquettes and even experimental demonstrations are used to teach the concept of adsorption to students with special needs (Maryanti et al., 2020a). However, there has been no research on teaching the concept of adsorption to vocational school students.

Then, the purpose of this study was to demonstrate an innovation in the distance learning process. Specifically, we introduced an experimental demonstration with a video for improving students' understanding. This is for supporting the teaching process in the case of practicum in vocational school under specific conditions such as the COVID-19 pandemic. As a model, we used to teach the adsorption isotherm of carbon microparticles. Carbon microparticles were selected as the adsorbent because they can be prepared easily from daily products, making it easier for the students to follow and retry the preparation procedure. Carbon also has a porous structure, making it easy in adsorbing pollutants. Indeed, this can make adsorption of carbon to be easily observed by students.

Different from other studies, the novelties of this study were:

i. The exploitation of innovation in the distance learning process by combining experimental demonstration and video as the teaching media, which is prospective for being applied during the COVID-19 pandemic (Maryanti et al., 2020b). The teaching was done to vocational school students in West Java Indonesia.
ii. The subject of the teaching process is the preparation process for making carbon particles, which can be done using largely available agricultural waste. For instance, this study used apple skin (*Malus sylvestris*) as the carbon source since apple is largely available in Indonesia (recorded 55.890 tons per year to produce apple in Indonesia in 2017). Apple skin was selected because it is contained as much as 42.308% of the apple's body (Yulistria, 2017),
iii. The type of adsorbate (molecules for being adsorbed onto the carbon) using turmeric. While other reports usually used a harmful dye or chemical as the adsorbate, turmeric is harmless and largely available in tropical countries such as Indonesia.
iv. We asked students to pay attention to the experimental demonstration inside the video learning media. Since the experiments were done using available materials and processes that can be found in daily life, students can do the preparation of carbon microparticles as well as analyse the experimental data by themselves. Thus, they can feel what phenomena happen, explore the experiment process, and calculate data as well as mathematical analysis. All the experiments were done in the distance learning process.

In this study, the subjects were focused on understanding the successful teaching process, in which we used the control class and the experimental class. The control class was done by giving a conventional teaching process using video only (without experimental demonstration). The experimental class was given a pre-test, an experimental video demonstration, and a post-test. The results of experimental learning can increase students' knowledge. From the results, we believe that experimental demonstration with video can be applied to teach other lessons, especially during distance learning.

2. Literature Review

2.1 Vocational Curriculum on Adsorption

The curriculum is a set of educational programs planned and implemented to achieve educational goals (Ibrahim, 2012). The curriculum objectives include four aspects of competence, namely (1) aspects of spiritual attitude competence, (2) social attitudes, (3) knowledge, and (4) skills. These aspects of competence are achieved through intracurricular, co-curricular, and extracurricular learning processes (Rusyani et al., 2021).

In vocational high schools in Indonesia, some materials must be mastered by students. One of them is about adsorption. Adsorption is taught in class X (vocational high school in the 1st year) in the curriculum in Indonesia. This subject material is important to be taught because adsorption material is one of the basic knowledge areas that must be mastered before studying the next subject material. In addition, adsorption material is closely related to phenomena that occur in the surrounding environment in daily life. The curriculum in vocational high schools in Indonesia consists of core competencies (KI) and basic competencies (KD) (Suherman, Maryanti, & Juhanaini, 2021; Maryanti et al., 2021a; Maryanti et al., 2021b). Each core competency consists of several basic competencies.

Table 1 describes the curriculum on adsorption in vocational high schools, particularly in industrial chemistry. Adsorption learning is found in chemical engineering operations subjects at KI 3 and KD 3.3 and 3.4 (Dharmawan & Herdyastuti, 2019).

Table 1 - Curriculum on adsorption materials in vocational high school (Dharmawan, & Herdyastuti, 2019)

Code number	Core Competencies (KI)	Code number	Basic competencies (KD)
3	Understand, apply, analyse, and evaluate factual, conceptual, basic operational, and metacognitive knowledge according to the field and scope of work in Chemistry	3.3	Implement operations absorption equipment following standard operating procedure (SOP)
	Industry at the technical, specific, detailed, and complex level, relating to science, technology, arts, culture, and humanities in the context of developing one's potential as part of the family, school, world of work, national, regional, and international citizens.	3.4	Implement the operation of absorption equipment following standard operating procedure (SOP)

2.2 Underpinning Theory Related to the Study

Video has many advantages over traditional education including convenience, efficiency, and individualised learning (Pilieci et al., 2018; Maulid & Sakti, 2022). Using experimental demonstration videos, students can repeat the videos themselves and learn the concepts given extensively. Experimental demonstration videos can stimulate curiosity and increase student interest in learning, allowing students to obtain more information.

Vocational schools aim to form professional identities or expertise in students (Rosina et al., 2021). Vocational schools are filled with skills-building activities needed in the world of work. The Covid-19 pandemic has created new changes in learning in vocational schools. Social restrictions require learning to be transformed from traditional to online. Online learning has a great impact on vocational students. Many competencies are complex for vocational students to acquire. One of them is in industrial chemistry vocational schools, and students do not get the learning experience in laboratory work they should get at school. This condition requires teachers to look for new learning strategies to teach laboratory work competencies by distance learning.

Currently, the only way to teach distance learning laboratory work competencies is using technology. Various technologies can emulate real laboratories, such as remote-control labs, virtual labs, and video-based labs (Gamage et al., 2020). Experiments at remote control labs were conducted using the internet to control experiments externally through several media (Shah et al., 2021). Virtual labs use virtual reality and simulations that overview real laboratories (Hernández-de-Menéndez, Guevara, & Morales-Menendez, 2019). Video-based labs use video to present steps from real laboratory activities (Sulisworo & Maruto, 2020). Video-based labs combine real laboratory activities with the use of technology. The teacher or tutor conducts real experiments in the laboratory, and all activities carried out in the laboratory are recorded so that students can know the dynamics that occur in the laboratory. By watching the video, students can visualise and imagine the whole process of the experiment and its environment. Therefore, video-based labs are better than the previous two technologies for delivering real laboratory work processes to the students.

Video-based labs, also known as experimental demonstration videos, have many advantages over traditional education, including convenience, efficiency, and individualised learning (Pilieci et al., 2018). By learning to use experimental demonstration videos, students can repeat the videos by themselves and learn the concepts given extensively. An experimental demonstration video can stimulate curiosity and increase student interest in learning, then allow the students to obtain more information. An experimental demonstration video can be a practicum module to guide students to self-experimentation at home if possible, or guide students to do the same practicum in the laboratory if they are required to do so. Experimental demonstration videos can help students to develop their potential in laboratory work and help students to have skills that can support them when entering the world of work. Thus, experimental demonstration videos have the potential to be used in teaching the concept of adsorption to chemical vocational students. Experimental video demonstrations can present the theory, the adsorption practicum process, and the interpretation of the experimental data. In this research, an experimental demonstration video was used as a strategy to teach adsorption practicum with distance learning.

2.3 Theoretical Knowledge of Carbon Microparticle Adsorption Taught in Vocational High School

In this section, we explained the theoretical knowledge of adsorption taught in vocational high school. To support the experiment, this study used four types of isotherm adsorption models: Langmuir, Freundlich, Temkin, and Dubinin-Radushkevich. The isotherm adsorption model predicts the phenomena during the process of adsorption, based on the amount of solution adsorbed per mass of adsorbent at equilibrium and on the concentration of the adsorbate. Detailed information about adsorption models is explained in previous studies (Ragadhita & Nandiyanto, 2021).

Langmuir model assists quantitative analysis for the formation of a single layer adsorption model on the outer surface of the adsorbent. When the adsorbate is attached to the adsorbent surface, no more adsorption process from other adsorbates occurs. The Langmuir isotherm model also assumes adsorption on a surface without homogeneous surface interactions between the adsorbate molecules. The Langmuir model is predicted using equations (1) and (2):

$$\frac{1}{q} = \frac{1}{q_m.K_L}\ \frac{1}{C} + \frac{1}{q_m} \quad (1)$$

$$R_L = \frac{1}{1 + K_L C_e} \quad (2)$$

where K_L is a constant in the Langmuir model; q_e is the number of molecules adsorbed per gram at equilibrium (mg/g); q_m is the adsorption capacity of the single layer (mg/g); R_L is the adsorption factor, explaining:

(i) $R_L > 1$ is an unfavourable adsorption process (promotes desorption).
(ii) $R_L = 1$ is a linear adsorption process (the adsorption isotherm depends on the amount and concentration adsorbed).
(iii) $R_L = 0$ is an irreversible adsorption process (adsorption is too strong).
(iv) $0 < R_L < 1$ is the preferred adsorption process (adsorption can be controlled under certain conditions).

Freundlich's adsorption isotherm model is the most widely used non-linear adsorption model, which is under multilayer adsorption with a heterogeneous energetic distribution of the active site on the adsorbent and calculates the interactions between adsorbed molecules. Multilayer adsorption can be applied in this model isotherm. Adsorption energy is a function of the adsorption process on the adsorbent, which is expressed by equation (3):

$$ln\ ln\ q_e = ln\ ln\ K_F + \frac{1}{n}\ ln\ ln\ C_e \quad (3)$$

where K_F is the Freundlich constant as an indicator for estimating the adsorption capacity, and n is the adsorption intensity, which can predict the adsorption process using the following phenomena:

(i) $n < 1$ is for chemical adsorption.
(ii) $n = 1$ is for linear adsorption (adsorption depending on the amount and concentration adsorbed can also be a combination of chemical and physical adsorption processes)
(iii) $n > 1$ is physical adsorption.
(iv) $1/n < 1$ is normal adsorption.
(v) $1/n > 1$ is cooperative adsorption.
(vi) $1 < 1/n < 0$ is the preferred adsorption process (inhibits the desorption process).
(vii) $0 < 1/n < 1$ is normal adsorption (controllable under certain conditions).
(viii) If $1/n$ approaches zero, the adsorbent surface is more heterogeneous.

Temkin's model discusses the correlation between indirect adsorbate interactions and adsorption isotherms. The adsorption heat of all adsorbate molecules in the layer is a function of the interaction of the adsorbates. The model describes the factors that are explicitly present in the conditions of the adsorbate interaction. By adding the assumption of using very low concentration adsorbate, the heat of adsorption of all the molecules in the layer serves as temperature. The Temkin model is expressed by equation (4):

$$q_e = B_T\ (ln\ ln\ C_e) + (B_T\ ln\ ln\ A_T) \quad (4)$$

where A_T is the equilibrium constant in the Temkin isotherm model, and B_T is the Temkin isotherm constant, explaining:

(i) $B_T < 8$ kJ indicates physical adsorption.
(ii) $B_T > 8$ kJ indicates chemical adsorption.

The Dubinin-Radushkevich model is generally applied to regulate the adsorption mechanism based on heterogeneous surfaces. The Dubinin-Radushkevich model is calculated using equation (5):

$$ln\ q_e = ln\ q_s - (\beta\varepsilon)^2 \quad (5)$$

where q_s is the theoretical isotherm saturation capacity (mg/g), β is the Dubinin-Radushkevich isotherm constant which corresponds to the average free adsorption energy per mole of adsorbate, and ε is the Polanyi potential associated with equilibrium conditions.

3. Materials and Methods

3.1 Carbon Microparticles Production and Adsorption Analysis

The materials used in this study are Malang apple skin (from local markets in Kuningan, West Java, Indonesia), turmeric (obtained in local markets in Kuningan, West Java), and mineral water (Swalayan market, Kuningan, West Java, Indonesia). The experimental methods were carried out by cleaning, peeling, and drying the Malang apple peels in an electrical furnace (200°C) for 40 minutes. The carbon was then saw-milled and sieved into a specific particle size (i.e., 55, 74, 100, 200, and 500 µm) using the similar apparatus in our previous work (Nandiyanto et al., 2018). To remove any impurities, the prepared carbon particles were washed using a centrifugation process. Carbon particles were dried using an electrical furnace at a temperature of 80°C.

Curcumin was used as the adsorbate model. Curcumin solution was prepared by diluting turmeric powder into 50 mL of water (with a concentration of 10, 30, 50, 70, and 90 ppm). An adsorption test was carried out by adding 0.10 g of carbon microparticles into the curcumin solution. The solution was stirred for 5 minutes. After one hour, the solution was filtered using a filter paper, and the concentration was measured using a total dissolved solid (TDS) metre (Model E-1 portable). The obtained concentration data were plotted and compared with the standard adsorption isotherm models: Langmuir, Freundlich, Temkin, and Dubinin-Radushkevich. Detailed step-by-step experiments for the adsorption are explained in previous studies (Anshar, Taba, & Raya, 2016; Khuluk & Rahmat, 2019). All materials and apparatuses can be easily purchased from the local market, both online and offline markets in Indonesia.

3.2 Teaching Method

The subjects of this research were divided into the control and experimental classes. The control class was done to 30 vocational school students (grade 10, 11, and 12; 8 male and 22 female; the average age is 17 years old). The experimental class was done for 30 vocational school students (grade 10, 11, and 12; 6 male and 24 female; the average age is 17 years old). Basic information about students was also collected to support this study, including IQ scores, and average scores for mathematics, chemistry, physics, and biology. The experimental demonstration was delivered and recorded into a demonstrational video. The video contained an explanation of the problem of waste and its impact on the environment, social, and economy, as well as an explanation of the potential of Malang apple peel waste to be used as the source of carbon adsorbent, the concept of adsorption, the steps for making apple peel waste into carbon for adsorbent, the steps for testing carbon adsorption process, the results of the test, and how to analyse the results.

To the control class, we gave only a pre-and post-test without being given an experimental demonstration video. In the experimental class, we gave three stages:

(i) Analysing students' basic knowledge about the concept of adsorption by giving students pre-test questions.
(ii) Students were given a video demonstration explaining the concept of adsorption, making adsorbents from Malang apple skin carbon, and the results of the adsorption test (using turmeric as a model of dye solution).
(iii) After being given the video, students were then given a post-test to observe their understanding of the concept of adsorption.

The questions for pre-and post-test were the same, consisting of 15 questions. The type of questions made were statements that must be determined to be true or false. Students must analyse whether the statement in the question is true or false. Both pre-and post-test used a score scale of 0 for the wrong answer and 1 for the correct answer. Each question's average score was converted to a percentage and tabulated.

4. Results and Discussion

4.1 Isotherm Adsorption of Carbon Microparticles Prepared from Malang Apple Peels Taught in This Study

Figure 1(a) shows the photograph image of carbon microparticles prepared from Malang apple skin used in this study. Figure 1(b) shows the particle sizes in the range between 55-500 µm. The largest percentage of particle size distribution is 74 µm, reaching 29.36%.

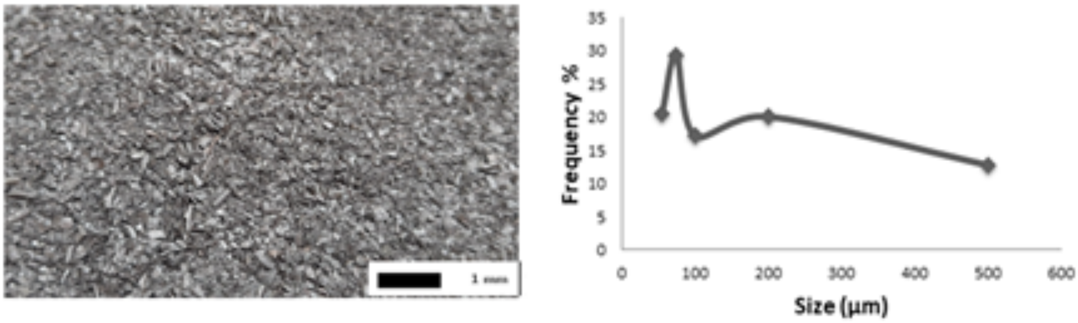

Fig. 1 - (a) carbon microparticle; (b) percentage of particle size distribution

In this study, the adsorption characteristics were analysed using four isotherm models, namely Langmuir, Freundlich, Temkin, and Dubinin-Radushkevich. Table 2 provides detailed parameters of the four isotherm models. It was obtained that the most suitable isotherm model to represent the adsorption mechanism was the Langmuir model. The Langmuir isothermal model assumes that the adsorbent surface was homogeneous, and the adsorption energy was equivalent for each adsorption site. The Langmuir model was ideal and irreversible. Thus, it was only limited to the formation of a single layer. From the experimental data, it was obtained that R^2 values were between 0.49 and 0.84, informing the Langmuir model is not fit. R_L was between 0 and 1, indicating that the process is the normal adsorption and can be controlled under certain conditions (Jawad, Kadhum, & Ngoh, 2018; Pambayun et al., 2013).

The adsorption was compatible with the Freundlich and the Temkin models. From Freundlich's parameters, the adsorption process occurs with chemical and physical processes. From the Temkin parameter, the B_T value was higher than 8 kJ, indicating that this process is the chemical adsorption process. The Dubinin-Radushkevich isotherm model was the lowest level of compatibility compared to other models. The Dubinin-Radushkevich model further explains the adsorption process with a pore-filling mechanism, while the apple peel carbon that we used did not go through an activation process. Thus, the pores on the carbon were not fully activated. Based on the Dubinin-Radushkevich's parameters in the study, we obtained E < 8 kJ, indicating that there is a chemical process (Ragadhita et al., 2019).

Table 2 - Isotherm Model

Model	Parameter	Particle size					Notes
		55	74	100	250	500	
Langmuir	q_m	-5.0151	-4.9104	-5.0768	-5.5772	-3.7278	0 <R_L<1, adsorption can be controlled under certain conditions.
	K_L	0.0052	0.0047	0.0041	0.0037	0.0093	
	R_L	0.9727	0.9717	0.9721	0.9762	0.9556	
	R^2	0.4947	0.8332	0.5931	0.6208	0.4987	
Freundlich	n	1	1	1	1	1	n=1, linear adsorption (chemical and physical processes can be combined).
	$1/n$	1	1	1	1	1	
	K_f	0.2027	0.2027	0.2027	0.2027	0.2027	
	R^2	0.6359	0.3165	0.8714	0.4149	0.2606	
Temkin	A_T	1.0002	0.9994	0.9962	0.9967	0.9991	B_T>8 kJ, chemical adsorption.
	β_T	1529.7431	1123.66 64	750.5974	777.375	1001.1201	
	R^2	0.8038	0.2738	0.8345	0,3481	0.0822	

Table 2 - Continue

Model	Parameter	Particle size					Notes
		55	74	100	250	500	
Dubinin - Radushckevich	q_s	5.3946	6.768	9.7124	9.2859	7.1171	E<8 kJ/mol, physical adsorption
	E	-0.5961	-0.4352	-0.2788	-0.2949	-0.4195	
	R^2	0.3485	0.6622	0.8654	0.4661	0.2909	
	β	-0.4194	-0.5745	-0.8967	-0.8477	-0.596	

4.3 Teaching Process to Vocational School Students

Figure 2 shows the students' IQ test results. The results were normally distributed and most of the students had normal to average IQ. This showed that this study's subject can be accepted. Normal IQ indicated intelligence, the ability to think logically, and being able to receive science material well (Anggraeni et al., 2020).

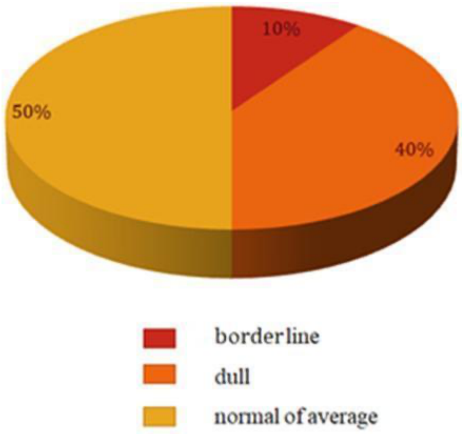

Fig. 2 - Distribution of student's IQ

Table 3 shows the students' abilities in fundamental science subjects (i.e., Mathematics, Chemistry, Physics, and Biology) with an average score of above 75. There was not much difference between those subjects, except for biology. Several majors in vocational institutions did not provide well in biology classes, resulting in low Biology scores (39.93). This is because most vocational schools relate to the engineering aspect. Therefore, this value was sufficient for describing the background of students' learning abilities.

Table 3 - The average score in several subjects of students at school

Subject	Average Score
Mathematics	81.44
Chemistry	77.13
Physics	76.34
Biology	39.93

Table 4 shows the students' pre-and post-test scores. Before applying video to the students, the average pre-test score of all students was below 70. There were the conditions for increases in the score after the video learning media was given. This provided that the method effectively improved students' understanding of the condition of distance learning. Further improvements in the score were found when the teacher applied video learning containing experimental demonstrations. The cumulative average gain for video learning containing experimental demonstration was 17.67, indicating an overall improvement between the pre-and post-test scores. A pre-test can promote students' interest in upcoming events like a learning experience or a post-test in general (Kim & Wilson, 2010). The pre-test may inform the individuals of related subjects, allowing them to concentrate on one the researchers intend to analyse (Anggraeni et al., 2020).

Table 4 - Score (%) obtained from students by the experimental demonstration method

No	Problems	Score %					
		Control Class			Experimental Class		
		Pre-test	Post-test	Gain Control Class	Pre-test	Post-test	Gain Experimental Class
1.	Adsorption is a process, in which the dissolved components in the fluid move to the surface of the adsorbing solid (adsorbent).	90	80	-10	90	90	0
2.	If the adsorbent is a porous material, the pores on the adsorbent can be used for adsorbing pollutants in water.	40	70	30	80	95	15
3.	The successful adsorption in adsorbing pollutants in water can be observed from the change in the value of concentration (such as % or parts per million (ppm)). The increase in concentration indicates that the pollutant has been successfully absorbed by the adsorbent.	30	30	0	30	55	25
4.	Adsorbents can be made from biomass. One of them is Malang apple skin. When using Malang apple skin as the biomass for adsorbent, it must be converted into carbon material.	100	90	-10	85	95	10
5.	Malang apple skin has the potential to be developed into an adsorbent in Indonesia due to its limited quantity.	80	80	0	70	90	20
6.	Carbonisation is the process of converting biomass into carbon. The stage of making carbon is also aimed at eliminating existing bacteria.	20	40	20	35	65	30
7.	The process of producing adsorbent from Malang apple skin is the drying - carbonisation - filtering - washing - drying - adsorption test.	40	90	50	60	90	30
8.	The carbonisation process can remove organic material from the biomass. Loss of organic material can leave pores on the carbon.	40	50	10	75	80	5

Table 4 - Continue

No	Problems	Score %					
		Control Class			Experimental Class		
		Pre-test	Post-test	Gain Control Class	Pre-test	Post-test	Gain Experimental Class
9.	Carbonisation requires a certain temperature. In the carbonisation process of Malang apple skin, the temperature used is a constant temperature at more than the temperature burning point (such as 220°C in 40 minutes).	40	90	50	35	70	35
10.	Before being used as an adsorbent, carbon particles must be washed. In the carbon washing process, the removed carbon particles are those that settle and drift.	40	40	0	50	45	-5
11.	The adsorption process relates to the size of the adsorbent. The optimum carbon particles used in this adsorption trial were 150 um particle size.	80	80	0	70	85	15
12.	The adsorption process relates to the surface area of the adsorbent (absorbent material). If the carbon particles are very small, the carbon particles will pollute the water.	40	40	0	50	75	25
13.	The adsorption process relates to the surface area of the adsorbent (absorbent material). The smaller particle size will increase the adsorbent's ability to absorb pollutants.	60	90	30	75	85	10
14.	The ability of the adsorbent to reduce the concentration of water depends on the number of carbon compounds that are introduced into the polluted water. The more carbon particles put into the water will bring the greater decrease in concentration.	20	70	50	30	60	30
15.	Turmeric solution can be made as an adsorbate model. Carbon can adsorb turmeric, as proven by the reduced concentration of the solution.	70	100	30	75	95	20
	Average	**50.67**	**69.33**	**16.67**	**50.67**	**78.33**	**17.67**

To understand the results from the pre-and post-test, we analysed the questions given to students:

(i) The first question showed that the gain has not changed too much. This could be owing to the questions' low difficulty level, which allowed students to do well on both the pre-and post-tests.

(ii) There was no gain on question number 2 which assessed the adsorption process of solutes in fluids by adsorbents. This indicated that even before watching the experimental video, students already understand the concept of it.
(iii) Question number 3 discussed the completion of the adsorption process which was characterised by a decrease in concentration. In this question, a big gain was obtained, implying that the experimental demonstration video succeeded in conveying the concept.
(iv) Question number 4 showed a gain of 10. In question number 4, students were able to answer the pre-test question well. The video demonstration could further enhance students' understanding of the adsorbent production from biomass, which must first go through the carbonisation stage.
(v) Question number 5 discussed the possibility of Malang apple skins being used as adsorbents. The question shows a gain of 20. The video experimental demonstration presented a discussion of Indonesian statistical data related to Malang apple skin waste in Indonesia so that the video can convey information about the great potential of Malang apple skin as an adsorbent.
(vi) In question number 6, the gain from pre-test to post-test showed a high value, but the average post-test score was still below 70. The video demonstration discussed that carbonisation is a process of converting biomass into carbon, but the goal is to produce pores, not to eliminate bacteria.
(vii) The video for the experimental demonstration was successful in conveying an understanding of the procedure for making adsorbents from Malang apple skin waste. This was indicated by the high gain in question number 7.
(viii) In addition, in question number 8, the gain did not change too much. The question concerned the process in the carbonisation of biomass that can create pores on carbon. The gain did not vary significantly because of the video's lack of explanation of the subject.
(ix) The largest gain in this study was obtained on question number 9. The question was about the temperature used to carbonise the apple skin. In the demonstration video, the carbonisation temperature was discussed very clearly, so that the video could increase students' understanding of the specific temperature needed for the carbonisation process.
(x) In question number 10, the gain was negative. The question discussed the carbon microparticles' washing process before being used as an adsorbent. The negative gain can be caused by the misinterpretation of the sentences used in the questions regarding carbon washing. In the video, it was explained the carbon washing stage for cleaning carbon particles. The carbon microparticles were settled during the process. In the question, the sentence was presented as "in the carbon washing stage, the carbon particles that are removed are those that settle and float". The sentence traps students' understanding, causing students to give incorrect answers.
(xi) In question number 11, the gain did not change too much. It could be caused by students failing to pay attention to the demonstration video during the experimental stage; Thus, there were important parts that were not caught by students.
(xii) In question number 12, the gain was 25. This indicated that the video experimental demonstration was effective in conveying that the small size of the carbon particles will increase the adsorption efficiency instead of polluting the solution.
(xiii) The gain in question number 13 showed not too much change. Question number 13 discussed that a small particle size could increase the adsorption capacity. Video demonstration was effective to convey the concept of particle size and particle surface area to adsorption capacity.
(xiv) The video was also effective to convey the concept. The more carbon compounds put into the water gave greater decreases in concentration. This effectiveness was shown by the high gain in question number 14.
(xv) The good gain was also found in question number 15. This question discussed the turmeric solution which was used as a model of the adsorbate. The successful adsorption was proven by decreasing the concentration of the solution. The gain showed that the experimental demonstration video succeeded in conveying the concept of adsorption to students.

Based on the test results in the control class, the control class has lower test results (compared to the experimental class). Even the gain of the post-test results between the control class and the experimental class shows a large difference. This indicates that students in the control class do not understand the concept of adsorption well without being shown an experimental demonstration video. However, in question number 4, regarding the biomass carbon to be used as an adsorbent, students in the control class obtained a higher score than the post-test results of students in the experimental class. This could be because the questions given were relatively easy and general.

In general, the experimental videos given to these students have a positive impact on improving their understanding of their learning about isotherm adsorption characteristics and phenomena. The video provided an explanation of abstract material accompanied by the animation, figure, motion, text, and audio. The video helps the students to imagine the concept and increase their focus on the material to understand the concept transferred (Hidayat et al., 2020). It also aided students in comprehending the connection between theory and experimental activities (Girault et al., 2012).

A t-test was used to determine whether there was a significant difference between the pre-and post-test scores. It was found that the t-critical two-tailed value was 2.04 which was higher than the t statistic value (-2.52). Therefore, the students' understanding of the matter was found significantly improved. The increases in post-test scores were caused by learning using the video demonstration method to attract more students' interest in learning (Ditta et al., 2020). The experimental demonstration video provided visual and audio experiences (Andersen & Nielsen, 2013), which can increase students' enthusiasm when learning. This video experimental demonstration method is one of the solutions for distance learning during the COVID-19 pandemic. This experimental demonstration video can be replayed several times until students understand the concept of adsorption. Since the experiments were done using available materials and processes that can be found in daily life, students can do the preparation of carbon microparticles as well as analyse the experimental data by themselves. Thus, they can feel what phenomena happen, explore the experiment process, and calculate data as well as mathematical analysis.

This study has limitations in detecting the possibility of misconceptions. The misconception is the differences in the students' understanding of the actual theory or phenomenon explained in the video. The misconceptions are related to distance learning techniques carried out using demonstration videos. Learning was carried out independently by students, and changes in student knowledge are measured to prove learning outcomes. However, misconceptions may occur when students try to understand the concepts presented in the video. Students may have misconceptions about adsorbate-adsorbent, the adsorption process, the appropriate model for the adsorption process, and misconceptions in the laboratory work shown in the video. Misconceptions can occur with the theory that students' prior knowledge can affect the new knowledge learned by the student (Üce & Ceyhan, 2019). The knowledge gained by students may be different from the actual concepts put forward by experts. The misconceptions that occur during distance learning are related to the students' ability to conduct lab work. Misconceptions can affect the success of students' practice on adsorption when students have the opportunity to do. Further research is needed to identify student misconceptions after learning using this experimental demonstration method.

5. Conclusion

The demonstration of distance learning innovation in teaching chemistry in vocational schools using the concept of isotherm adsorption of carbon microparticles has been done. The experimental demonstration video for improving the teaching process about adsorption isotherms of carbon microparticles to vocational school students was investigated. The idea of this research used apple peel (Malus sylvestris) as a carbon source, turmeric as an adsorbate model, and adsorption isotherm learning which was done to teach 60 vocational students in West Java, Indonesia. The learning outcomes of vocational school students showed increases in the post-test scores after students learned the concept of adsorption from the experimental demonstration video. The video media improves students' understanding, which is prospective for the distance learning process. However, additional experimental demonstrations inside the video learning media enhanced students' interest in particular subjects and motivated them to learn more about the teaching subject, which became an innovation in the distance learning process.

We conclude that the experimental demonstration video was effective for teaching and can increase students' knowledge. This result has a correlation with Technical and Vocational Education and Training (TVET) where the experimental demonstration video can reflect the actual experimental process to the student and help students develop skills appropriate to work in chemistry related to adsorption. Experimental videos can provide an overview for students of the laboratory process even though students cannot do a practicum at school. In addition, experimental demonstration videos can even direct students to do an independent practicum at home, so that students can improve their laboratory abilities. We believe that these experimental demonstrations inside video learning media are prospective for being applied to teach other subjects in distance learning. This study has limitations in detecting the possibility of misconceptions that can occur when the student carried out distance learning techniques carried out using demonstration videos. Further research is needed to identify student misconceptions after learning using this experimental demonstration method.

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