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Online Learning's Impact on Senior High School Students in Chemistry during COVID-19 Lockdown in Indonesia

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Abstract: We determined how well high school students at a state school in Indonesia achieved academically after receiving chemistry instruction using an online learning method throughout the COVID-19 pandemic. We used the pre-experimental research method with 1 group design. The participants were 34 students, consisting of 12 males and 22 females. A cognitive achievement questionnaire was used for the survey. Parametric tests were used to analyze the data because the Shapiro-Wilk normality test indicated a value of 0.138. Equal variances were found with Levene's test (0.576). The variance was not different between genders. The cognitive tests after the online learning showed no significant differences between genders (t-test significance > 0.05). The study's findings supported the validity of online learning for Indonesian students.

Keywords: Online Learning, Gender, Chemistry, Senior high school

1. Introduction

COVID-19 influenced people's lives in Indonesia (WHO, 2020). Presidential Decree 11 of 2020 on March 31, 2020, declared the COVID-19 Public Health Emergency (Presidential Decree of the Republic of Indonesia 2020-a), which required statutory prevention efforts. The COVID-19 pandemic affected the central government, regional government, the commercial sector, and all sectors of Indonesian society (Presidential Decree of the Republic of Indonesia 2020-b). The workplace was considered as the locus of infection so workers could not gather (Government Regulation 21 of 2020). Schools were supposed to provide inline learning by the Indonesian Minister of Education's Circular of Education, number 4 (2020), item 2: *"Distance learning from home gives students a meaningful learning experience without the pressure of completing all curricular successes for class progress and completion, and the teacher provides qualitative feedback and value for evidence or products from home learning activities without scoring" (Minister of Education and Culture of the Republic of Indonesia 2020).* Thus, teachers were expected to provide online learning to students according to the circular. To meet these expectations, the teachers used learning strategies applicable during this pandemic. During the pandemic, teachers used blended learning as a learning approach for their online classes. We explored the gender differences in online learning outcomes during the pandemic using the Indonesian university entrance exam questionnaire.

2. Literature Review

Blended Learning is a hybrid course that delivers 30–79% of its curriculum online (Muller & Mildenberger 2021). In offline or hybrid learning, blended learning has been implemented in elementary schools. Google Classroom, Rumah Belajar, Kipin School, the Web, and Edmodo are the online learning tools that support and construct a learning environment (Sari 2021). Despite its inconsistencies, "blended learning" is used to describe various courses of study, educational techniques, and technological tools (Hrastinski 2019). Kiviniemi (2014) investigated that in health science classes, a blended learning method using the Internet in the classroom was the most effective way to assist all students in achieving academically. However, several studies indicated that the outcome of blended learning was not different for students' genders significantly. Herliana et al. (2020) implemented blended problem-based instruction at a high school and showed no noticeable difference in the learning achievement of different genders. This result aligned with the research in Malaysia engaged in online education during COVID-19. There were five components of readiness: self-directed learning, computer/internet self-effectiveness, online communication self-effectiveness, learner control, and learner motivation. This study revealed that females were readier than males (Chung et al., 2020). Another research result on learning motivation showed that students of both genders were equally motivated to learn mathematics in university in blended learning (Simanjuntak et al., 2020). Nevertheless, in other blended learning studies, female students surpassed male ones in academic achievement. Hsiao (2021) suggested that online learning performance was determined by teaching satisfaction, self-learning

satisfaction, and course grades. In this study, female students had higher course scores than males in online learning performance. In the traditional and blended learning environment, female students had higher academic achievement than males on average (Kazu & Demirkol 2014). This was supported by 2016 online course research presenting that females were more active than males. More online activity, viewing or writing more posts, and writing longer posts on discussion forums were associated with higher final scores (Lowes et al. 2016). Based on such different results, we examined the gender difference in online learning outcomes of Indonesian students using a modified questionnaire that was adapted to the existing curriculum from the Indonesian university entrance exam. In the curriculum, 100% online teaching was offered with videos made by the teacher, and online classrooms such as Google Classroom, Google Meet, and WhatsApp were used. The teacher used these applications to teach and interact.

3. Methods

The participants were students from the second semester of the 11th grade at public Senior High Schools in North Sumatra, Indonesia. There were two groups of participants in this research. The first group comprised 40 students (13 males and 27 females) from different public schools who had learned chemistry. The second group included 34 students (12 males and 22 females). The participants' ages were 16–17 years old. The teacher in the class taught the students about the colloidal system, which was observed in this study. The participants completed pre- and post-tests Modified national exam questions for the entrance exam to state universities in Indonesia were used for the tests. The colloidal system was one of the chapters studied by class the 11th-grade students in the second semester of the 2013 curriculum. This colloidal system consisted of several sub-chapters, namely: (A) Colloids, solutions, and suspensions; (B) Various colloidal systems; (C) Properties of colloids; (D) Making colloids, (E) Colloids in everyday life.

The pre-experimental research method with 1 group design was adopted. We classified the questions into Bloom's taxonomy which consists of six stages: remember (C1), understand (C2), apply (C3), analyze (C4), evaluate (C5), and create (C6) from lower degree to the higher degree (Chandio et al., 2021). A questionnaire was created with 20 questions (items). We analyzed and modified the items before the survey. To validate the questionnaire, we asked three chemistry teachers who had taught for more than five years in senior high school to review. The teachers agreed with the questionnaire without any revision.

We used SPSS 22 to analyze the questionnaire items, including validity, item difficulty, and item discrimination. Validity refers to how well test results fulfill their intended purpose. Test findings are used to characterize the performance of a person or forecast a person's likelihood of success in a certain activity (Gronlund, 1977). Content validity is essential to guarantee an assessment's overall validity. As a result, a methodical strategy for best practices and evidence was employed for content validation (Yusoff, 2019). Validity was calculated as follows.

$$r_{xy} = N \sum XY - (\sum X)(\sum Y) / \sqrt{\{N \sum X^2 - (\sum X^2)\}\{N \sum Y^2 - (\sum Y^2)\}} \quad (1)$$

(r_{xy} = the correlation coefficient is sought
N = the number of test takers
X = variable value X (item score)
Y = variable value Y (item score))

The item difficulty and discrimination were determined using (2) (Islam & Usmani, 2017). Difficulty index or facility value or "P" value were calculated, too.

$$P = [(H+L) / N] \times 100 \quad (2)$$

(H = Number of students in the high-achieving group who answered the items correctly.
L = Number of students in the low-achieving group who answered the items correctly.
N = Total number of students in the two groups (including non-responders)) (Islam & Usmani, 2017)

A difficulty index between 30–70% is considered to be acceptable. Those items with values between 50 and 60% are ideal, while items with less than 30% (too difficult) and more than 70% (too easy) are unacceptable or need revision.

The discrimination index (DI) or Point Biserial (PB) was calculated using (3).

$$D = [(H-L) / N] \times 2 \quad (3)$$

A discrimination index metric shows how much a test item is discriminated between test takers who perform well and those who do not. The index ranges from -1 to 1 and is expressed as a fraction. Ideally, an item has a positive discrimination index of at least 0.2, meaning that high scorers are more likely to answer correctly and low scorers are less likely to do so. Investigating objects with negative indices is essential to see if they need to be corrected or correctly typed.

Item analysis was used to first check the feasibility of an item with acceptable validity (I_1). Second, to check the difficulty level and the discriminant with accepted or revised (A or R1). If one item did not match the first condition, validity, it was rejected. Then, if the item was valid, we checked for its item difficulty and discriminant. If a valid item was rejected due to its difficulty and was discriminated against, it did not meet the criterion for an excellent item. However, if the item status was revised, the item was modified and used for a test. Besides the item feasibility, we also used the level of Bloom's taxonomy to compare the items with the concept similarity. The question with a higher level of Bloom's taxonomy was preferred. Ten items were selected for five indicators. For each indicator, 2 questions were assigned to calculate students' scores.

4. Results and Discussion

4.1. Questionnaire

We modified the Indonesian university entrance exam for this study. The questions for cognitive achievement were selected. Several questions were taken from the following question bank for Indonesian students (Appendix) (Anwar, 2013).

1. UM-UGM Ujian Masuk-Universitas Gadjah Mada or in English, University Entrance-Gadjah Mada University
2. UMPTN Ujian Masuk Perguruan Tinggi Negeri or in English, State College Entrance Examination from different areas (Rayon) in Indonesia
3. Proyek Perintis or in English, Pioneering Project
4. UAN Ujian Akhir Nasional or in English, National Final Examination
5. EBTANAS Evaluasi Belajar Tahap Akhir Nasional or in English, National Final Stage Learning Evaluation
6. Ulangan Umum Sekolah or in English, General School Examination

The questions were selected from the Ganesha Operation (Johnson, 2002). The questions were relevant to the curriculum of the colloidal system in 2013. The questionnaire consisted of 20 questions with five indicators, and each indicator consisted of 4 questions. The level of Bloom's taxonomy for each question was shown under each indicator (Table I). In this research, we categorized the indicators as C1-C4:

Table 1. Questionnaire for colloidal system.

No	Subject Topic	Indicator	Bloom's Taxonomy				Question Number	Number of Questions
			C1	C2	C3	C4		
1	Colloidal system	1. Explain the type of colloid based on the dispersed phase and the dispersing medium.	2		2		1, 6, 12, 17	4
		2. Explain the role of colloids in the industry.	1		1	2	5, 9, 11, 13	4
		3. Observe and explain the properties of colloids.			3	1	2, 16, 18, 20	4
		4. Explain lyophilic colloids and lyophobic colloids and the difference between them both	1	3			3, 8, 10, 14	4
		5. Explain the making of colloids by condensation and dispersion.		1	2	1	4, 7, 15, 19	4
Total								20

4.2. Item Analysis

After choosing questions, they were validated. We analyzed students' scores using SPSS 22 and obtained the validity value, item difficulty, and item discrimination. Table 2 displays the results of the item analysis. The scores of female students were higher than those of male students.

Table 2. Students' scores for item analysis.

Gender	n	Mean
Male	13	69
Female	27	76

The item validity, item difficulty, and item discrimination were analyzed. Table 3 shows the feasibility of an item as item analysis results. In item validity, item numbers 1, 2, 7, 11, and 14 were rejected due to the value of I2. In item difficulty, item numbers 7 and 10 were rejected due to the value of R2. In item discrimination, item numbers 2 and 11 were rejected. Overall, seven items did not show eligibility: 1, 2, 7, 10, 11, 14, and 20. After excluding these seven items, thirteen items met the above criteria. However, we used only ten items for five indicators. Each indicator had 2 questions, making it easier to calculate students' scores. Questions 4, 5, and 6 were not selected due to similarity and the level of Bloom's taxonomy. The question with a lower level of Bloom's taxonomy was not preferred. Question 4 (C2) had a similar concept to questions 15 (C4) and 19 (C3). Question 5 (C1) had a similar concept to questions 9 (C4) and 13 (C4). Question 6 (C2) had a similar concept to questions 12(C3) and 17(C3). Finally, we excluded questions 4, 5, and 6. The final ten items selected in the test were question numbers 3, 8, 9, 12, 13, 15, 16, 17, 18, and 19.

Table 3. Item analysis.

Criteria	Item*																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Validity	I_2	I_2	I_1	I_1	I_1	I_1	I_1	I_1	I_1	I_1	I_2	I_1	I_1	I_2	I_1	I_1	I_1	I_1	I_1	I_1
Item Difficulty	R_1	R_1	R_1	A	A	R_1	R_2	R_1	R_1	R_2	R_1	R_1	R_1	R_1	A	R_1	R_1	R_1	A	R_2
Item Discrimination	R_1	R_2	A	A	A	A	A	A	A	A	R_2	A	A	R_1	A	A	A	A	A	A

* I_1 means valid if the significance < 0.05. I_2 means invalid if the significance > 0.05. For revised or refused criteria, *p* (difficulty index) is higher than 0.7 (too easy) or below 0.3 (too difficult). R_1 (when the p-value is higher than 70%) means revised, and R2 (when the *p*-value is less than 30%) is rejected. A means the item meets the criteria of item difficulty or item discrimination.

4.3. Learning Outcomes

The gender differences in online learning outcomes were tested. We used a cognitive achievement questionnaire to test the student's learning outcomes. The teacher instructed 34 students in online learning. After completing online learning sessions, the teacher tested students' learning outcomes. Because there were fewer than 50 students, we used the Shapiro-Wilk test to ensure that the scores were distributed normally. The data was expected because of significance > 0.05 as shown in Table 4.

Table 4. Result of normality test for student learning outcomes in pre-experimental design.

Achievement exam	*Kolmogorov-Smirnov*[a]			*Shapiro-Wilk*		
	Statistic	df	Significance	Statistic	df	Significance
	0.147	34	0.059	0.952	34	0.138

a. Correction of Lilliefors Significance

An independent t-test of parametric tests was used to analyze the gender effect on the test (Table 5).

Table 5. Result of independent sample *t*-test on gender from ten-item test in pre-experimental design.

	Statistics					*Levene's* test		*t-test* result		
	Gender	n	Mean	SD	SE	Significance	t-cal	df	Significance	Status
Test	Male student	12	82.08	12.873	3.716	0.576	0.158	32	0.875	No significant
	Female student	22	82.73	10.434	2.225					

According to the results, H_1 was rejected but H_0 was supported. That is, no gender difference was found in online learning outcomes (H_0). The independent *t*-test result on gender (Table 5) showed that the result was homogenous (Levene's test). Online

learning in high schools in Indonesia showed no significant effect on tests between genders. This result agreed with the previous study (Herliana et al., 2020).

5. Conclusions

The study result showed that there was no discernible difference between the different genders of the participants in online learning during COVID-19. In further research, it is required to have more participants to provide more accurate results regarding the effect of online learning. The preferred research variables are gender, motivation, and preparation.

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Appendix

COGNITIVE TEST

Subject: Chemistry

Class: 11th Science

Subject / Topic: Colloidal Systems

Time: 45 Minutes

Put a cross (X) on your answer sheet for the answer choice that you think is the most correct.

1. (Ref: Anwar, 2013 from State College Entrance Examination UMPTN 1999 Rayon A)

Milk is a dispersion system...

A. Solid substances in a liquid dispersion medium
B. Liquid substances in a liquid dispersing medium
C. Liquid substances in a gas-dispersing medium
D. Solid substances in a solid dispersion medium
E. Gas in a liquid-dispersing medium

2. (Ref: Anwar, 2013 from UMPTN 1989 Rayon B)

The symptoms or processes that are least related to the colloid system are...

A. Tyndall Effect C. Coagulation E. Electrolysis
B. Dialysis D. Emulsion

3. (Ref: Anwar, 2013 from General School Examination Ulangan Umum Sekolah 1997)

One example of a colloid that is classified as a lyophil is...

A. Jam C. Smoke E. Pumice stone
B. Gelatin D. Dew

4. (Ref: Anwar, 2013 from National final examination UAN 2003)

The colloids below, which are made by condensation, are...

A. Sol As_2S_3 is made by flowing H_2S gas into the $As_2 S_3$ solution
B. Gold soles are made by throwing electric sparks from Au electrodes in water
C. Sulfur sol is made by mixing sulfur powder with sugar and then placing it in water

D. $Al(OH)_3$ sol is made by adding $AlCl_3$ solution to the $Al(OH)_3$ precipitate

E. Jelly sol is made by placing agar powder in hot water

5. (Ref: Johnson, 2002; Anwar, 2013 from University Entrance-Gadjah Mada University UM-UGM 2004)

One of the important properties of colloidal dispersions, which are widely used in industry and biochemical analysis, is...

A. Principles of electrophoresis C. Brownian motion E. Peptization

B. Tyndall D. Homogenization effect

6. (Ref: Anwar, 2013 UMPTN 1999 Rayon C)

A colloidal system in which the dispersed phase is solid, and the gas dispersing medium is...

A. Smoke C. Cork E. Pumice stone

B. Mist D. Soap Scum

7. (Ref: Anwar, 2013 from National Final Stage Learning Evaluation EBTANAS 2001)

Making $Fe(OH)_3$ sol can be done by...

A. Mechanical C. Redox reactions E. Decomposition

B. Peptization D. Hydrolysis

8. (Ref: Anwar, 2013 from Proyek Perintis Pioneering Project 1983)

Among the substances below, which cannot form lyophilic colloids when dispersed in water, are...

A. Kanji C. Gelatin E. Jelly

B. Sulfur D. Soap

9. The following are some of the properties of colloids:

1. Tyndall effect; 2. Brownian motion; 3. Coagulation; 4. Electrophoresis; and 5. Dialysis.

Aspects of colloidal properties in the water treatment process to obtain clean water are...

A. 1 B. 2 C. 3 D. 4 E. 5

10. (Ref: Johnson, 2002 from Ganesha Operation)

A colloidal system whose particles do not attract solvent molecules is called...

A. Lyophil C. Hydrophile E. Lyophobe

B. Dialysis D. Electrophiles

11. (Ref: Anwar, 2013 from Ulangan Umum Sekolah 2004)

The event of water purification with alum is related to the colloidal properties...

A. Brownian motion C. Tyndall effect E. Adsorption

B. Electrophoresis D. Coagulation

12. (Ref: Anwar, 2013 from EBTANAS 1999)

A type of colloid in which the dispersed substance is liquid and the dispersing medium is gas is...

A. Gel B. Sol C. Foam D. Emulsion E. Liquid aerosol

13. The following are some properties of colloids:

1. Dialysis; 2. Coagulation; 3. Adsorption; 4. Tyndall effect; And

5. Protective colloid.

The process of eliminating body odor with deodorant and heating egg whites is the application of colloidal properties, respectively....

A. 1 and 3 C. 3 and 2 E. 4 and 5

B. 2 and 4 D. 3 and 4

14. Among the following colloids:

1 gelatin sol 2 metal sol 3 gelatin 4 sulfur sol 5 foam

What is classified as a hydrophilic colloid is...

A. 1 and 2 C. 1 and 4 E. 2 and 4

B. 1 and 3 D. 2 and 5

15. (Ref: Anwar, 2013 from EBTANAS 2002)

The following process for making colloids, classified as a condensation method, is...

A. Adding $AlCl_3$ solution to the $Al(OH)_3$ precipitate.

B. Adding a saturated solution of $FeCl_3$ to hot water

C. Passing a high voltage electric current to the $AuCl_3$ solution

D. Put the crushed sulfur powder into the water.

E. Add 95% alcohol to a saturated solution of calcium acetate

16. The following are several everyday phenomena that show the nature of colloids in life:

1. Dialysis process 4. Sugar whitening

2. fog in the mountains 5. The working process of diarrhea medicine

3. Formation of deltas at river mouths

The coagulation properties of colloids can be demonstrated in the example of event number...

A. 1 B. 2 C. 3 D. 4 E. 5

17. (Ref: Johnson, 2002; Anwar, 2013 from UMPTN 1990 Rayon B)

If air is bubbled into the soap solution, foam will form. The dispersed phase and dispersing phase in foam are, respectively...

A. Liquid, gas C. Gas, liquid E. Liquid, solid

B. Liquid, liquid D. Gas, solid

18. Consider the following example of the application of colloidal properties!

(1) Highlight car lights during fog (4) Gelatin in ice cream

(2) Formation of deltas at river mouths (5) Bleaching of sugar cane

(3) Dialysis process

An example of the application of adsorption properties is...

A. 1 B. 2 C. 3 D. 4 E. 5

19. The following colloids are made by condensation:

A. Grind the sulfur powder, then mix it with water

B. Gold sole is made by passing an electric spark through an Au electrode in water

C. Reacting $CuSO_4$ with Na_2S in water

D. Flowing H_2S gas into the SO_2 solution

E. Making soles by heating starch suspension

20. Following events:

(1) Formation of deltas at river mouths

(2) Refining granulated sugar

(3) Healing stomach ache with norit

(4) Water purification

This is an example of a colloid coagulation event, except...

A. 1 and 2 C. 1 and 4 E. 2 and 4

B. 1 and 3 D. 2 and 3

(Anwar, 2013; Johnson, 2002).

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