

# Learning Loss Analysis of Introductory Concepts of Chemistry for Students After The COVID-19 Pandemic

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**Abstract:** This study analyzes the learning loss of first-year students' chemistry concepts at FKIP, University of Mataram. The research sample was 112 first-year students taking introductory chemistry courses at FKIP University of Mataram, 14 male students (12.5%) and 98 female students (87.5%) – these students, as a whole, face two years of online learning in high school. The primary data in this study is the analysis of respondents' test results related to prior knowledge of chemistry concepts during one semester of lectures. The results showed that the idea of limiting reagents and percent composition showed the highest learning loss (53.57%), while the concept of moles and molar mass and matter showed the lowest learning loss percentage of 32.14%. Furthermore, the results of statistical tests show the relationship between the average score before the UTS implementation and after the UAS implementation. The previous lack of online learning to strengthen students' prior knowledge indicates the cause of learning loss in chemical concepts. Questionnaire analysis stated that education through WA groups, the duration of chemistry learning was low, and the lack of feedback given by teachers on assignments students were working on during the learning process strengthened the current conditions.

**Keywords:** Feedback; Learning chemistry; Learning duration; Learning loss; Prior knowledge

## Introduction

Since the onset of the COVID-19 pandemic, the education system in the world has experienced real disruption. The UNESCO report shows that around 1.6 billion students in 190 countries, or the equivalent of 94% of the world's student population, feel the effects of school closures (United Nations, 2020). This situation was not only handled by students. Teachers and education staff are also facing a transition period that requires them to carry out "emergency" learning which is not easy.

For students, the pandemic, which lasted for approximately two years, significantly impacted their study habits. This condition can have an impact on their reactions after the pandemic takes place (Bond, Bergdahl, Mendizabal-Espinosa, Kneale, Bolan, Hull, & Ramadani, 2021). Many students lose the skills necessary for learning, such as self-regulation and emotional

regulation (Händel, Stephan, Gläser-Zikuda, Kopp, Bedenlier, & Ziegler, 2020). Several studies show students feel frustrated, emotional disturbances to other mental disorders (Chakraborty, Mittal, Gupta, Yadav, & Arora, 2021; Cranfield, Tick, Venter, Blignaut, & Renaud, 2021; Chaturvedi, Vishwakarma, & Singh, 2021).

The pandemic requires teachers to use online methods as the only option (Bond et al., 2021). This condition was, of course, a challenge for teachers. Students and parent need only sometimes provide sufficient support for distance learning (Marinoni, Van't Land, & Jensen, 2020; Hamidi, Jumadi, Nurohman, & Febrian, 2023). The impact of this situation on student learning responses. Knowledge outcomes that are not as expected make teachers experience prolonged stress (Chakraborty et al., 2021; Cranfield et al., 2021).

The decline in students' knowledge and skills, or what is known as learning loss, is a real impact after the

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pandemic (Donnelly & Patrinos, 2022). Learning loss is defined as a decrease or decline in students' knowledge and skills when learning progress does not occur at the same level as in previous years (Pier, Hough, Christian, Bookman, Wilkenfeld, & Miller, 2021). Not only is learning loss in knowledge, but also experience a decrease in learning in laboratory work (Rengkuan, Simal, Leasa, & Maelan, 2022). First-year students or the 2022/2023 academic year were often referred to as the COVID-19 generation because their high school years took place during the COVID-19 pandemic, and they carried out learning at home. First-year students must program compulsory courses as a prerequisite for programming the following semester's classes. One of the mandatory subjects is introductory chemistry.

As with other science learning, introductory chemistry courses also have a hierarchy of concepts students need to master. Several basic ideas are learned by students while studying in senior high school. However, the pandemic condition requires teachers to use different learning methods so that evaluation related to mastery of concepts has yet to be carried out optimally. Until now, there has not been much reported on mapping the basic idea of "loss" in the field of chemistry.

Five factors were reported to affect learning loss, namely (1) changes in teaching methods, (2) opportunities to get an education, (3) lack of study time, (4) lack of feedback, and (5) emotional factors (Zhdanov, Baranova, Udina, Terpugov, Lobanova, & Zakharova, 2022):

#### 1. *Changes in Teaching Methods*

Online learning methods for a long time have made students re-adapt to face-to-face learning. However, several reports show that students experience many disadvantages with the online method even though this method was quite influential during the pandemic (Di Pietro, Biagi, Costa, Karpiński, & Mazza, 2020; Education Endowment Foundation, 2020).

#### 2. *Opportunity to Get an Education*

Online learning can take place effectively if students and teachers have adequate devices and internet access, and teachers get training and knowledge related to online education (García & Weiss, 2020). However, the different conditions of students and teachers in various places mean that distance learning cannot always be carried out optimally (Frenette, Frank, & Deng, 2020; Haeck & Lefebvre, 2020). For example, students from high-income families can provide all the facilities to compensate for the learning loss due to school closures. This situation is different from less able students (Angrist, Bergman, Brewster & Matsheng, 2020; Bacher-Hicks, Goodman, & Mulhern, 2021).

#### 3. *Lack of Study Time*

Online learning causes student learning time to decrease due to limited instruction in online education (Di Pietro et al., 2020). Less study time can cause a loss of understanding in students (Andrew, Cattán, Costa Dias, Farquharson, Kraftman, Krutikova, Phimister, & Sevilla, 2020).

#### 4. *Lack of Feedback*

Feedback is an essential step in monitoring student learning progress (Rouleau, Abla, Gibson & Simenson-Gurolnick, 2021). This stage provides information to the teacher regarding the parts that students have not done to improve learning performance (Wisniewski, Zierer, & Hattie, 2020). Online learning carried out during COVID-19 has reduced teachers' and parents' feedback on the learning process. The reduction of feedback causes distance learning to affect the loss of students' knowledge and skills (Azubuike, Adegboye, & Quadri, 2021).

#### 5. *Emotional Factors*

All human cognitive functions, such as perception, attention, learning, memory, reasoning, and problem-solving, are influenced by emotions (Tyng, Amin, Saad, & Malik, 2017). This function causes emotions to be one factor that affects learning loss in students (Dorn, Hancock, Sarakatsannis, & Viruleg, 2020; Rai, Akhtar, Singh, Bhatt, Verma, & Kar, 2021).

Analysis of learning loss requires many reports to ascertain the causes and ways to overcome learning loss in students (Anthony, Emiliana & Rohan, 2022). In general, learning loss can be measured in several ways. For example, Richmond, McCroskey, Kearney, & Plax (1987) used a questionnaire on students' perceptions of the teacher's use of behavior change techniques and their perceptions of their classroom learning. Student reports regarding cognitive ability can also be used to measure learning loss (Simal, Mahulauw, Leasa, & Batlolona, 2022). A total of two questions related to the concepts learned and to instructors who teach with a Likert scale of 1-10 (Chesebro & McCroskey, 2000). Using prior knowledge questions can also be an option for measuring learning loss (Hooker & Denker, 2014).

This study analyzes indications of learning loss in chemical concepts in first-year students.

## Method

This study uses a quantitative approach. The research process is shown in Figure 1 (Hooker & Denker, 2014; Richmond et al., 1987).

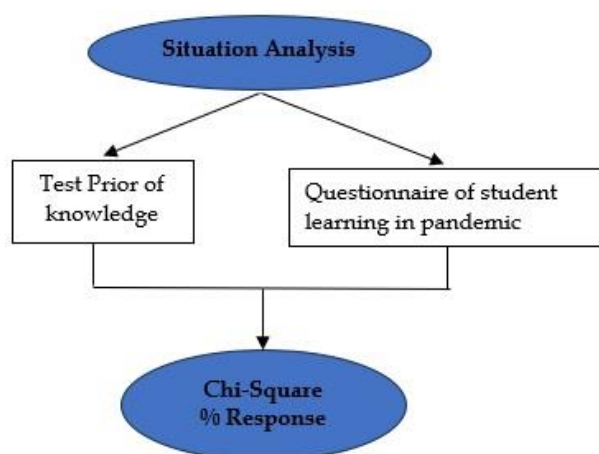


Figure 1. Research Methods

### Research Sample

This study used first-year student respondents who took introductory chemistry courses at the Mataram University FKIP. The number of samples was 112 samples 14 male students (12.5%) and 98 female students (87.5%).

### Situation Analysis

Based on the overall poll results, first-year students in the 2022/2023 class are taking online lectures while in high school. They get chemistry subjects according to the curriculum that applies in their schools.

Lectures are conducted for 16 weeks by explaining the basic concepts of chemistry according to the IQF curriculum. The main topics presented include introductions related to the matter, molecular structure, stoichiometry, chemical energetics, solutions, reaction rates, and chemical equilibrium. These topics cover the initial concepts that students have acquired at the high school level. The initial concept includes matter; properties of matter; mole and molar mass; percent composition; chemical reaction; empirical formula; molecular formula; and limiting reagent

### Data collection technique

Learning loss in this study is defined as a learning decline in the field of Chemistry. Learning loss is measured using concept tests that a student following the curriculum at the upper secondary level should have mastered. Data were collected by analyzing respondents' test results related to prior knowledge of chemistry concepts during one semester of lectures. Initial ideas were explored as previously described. Concepts no. 1-4 become the initial knowledge of lessons before the midterm exams, while concepts no. 5-8 become the initial knowledge of lectures after the midterm exams. The exam results, including Quiz, midterm exam, and final exam, were analyzed. An assessment score was given one if the answer was

correct and 0 if the answer was wrong. Score 1 was categorized as a student who does not experience learning loss, while score 0 is the opposite.

To know the causes of learning loss, collecting supporting data using a questionnaire related to the implementation of student learning while sitting in high school, according to the Chesebro & McCroskey instrument development (2020).

### Data analysis technique

The test results are tabulated with the percentage of learning loss expressed as the number of students who answered incorrectly on each concept. The relationship between concepts before and after the midterm exams was analyzed using the Chi-Squares test with the help of IBM SPSS Statistics 21. Finally, questionnaire analysis related to the implementation of learning is described as supporting data for student learning loss.

## Result and Discussion

Analysis of student test results shows that the concept of limiting reagents and percent composition shows the highest learning loss (53.57%). In contrast, the moles and mass molar, and matter shows the lowest learning loss percentage of 32.14% (Table 1).

Table 1. Percentage Learning Loss Introductory Chemistry Concepts

Concept	% Learning Loss
Matter	32.14
Properties of matter	37.5
Mole and molar mass	32.14
Percent composition	53.57
Chemical reaction	50.89
Empirical formula	37.5
Molecular formula	50.89
Limiting reagent	53.57

The statistical test results show that the score before and after the midterm exam offers a Chi-Square value of 87.5 with a significance probability value of 0.000, so there is a relationship between the average score before the midterm exam and after the midterm exam (Table 2).

Table 2. Chi-Square Tes

	Value	df	Asymp. Sig (2 sided)
Pearson Chi-Square	87.500 <sup>a</sup>	6	0.000
Likelihood Ratio	34.139	6	0.000
Linier-by-Linier	0.001	1	0.970
Association			
N of Valid Cases	112		

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .02.

The results of the questionnaire analysis showed that all students completed online learning for two years, namely in grades X and XI, and offline learning in class XII. The learning system uses more WA groups with 1-2 hours per week. As a result, more students do not get feedback from the assignments given, and more need to follow or find out when experiencing difficulties. The results of the questionnaire analysis are shown in Table 3.

Tabel 3. Questioner Analysis

Indicator	% Response
Students were learning using the WhatsApp group	72.32
Students were learning using google Classroom	27.68
Study duration 1-2 hours per week	65.18
The study duration is more than 2 hours per week	34.82
Get feedback on assigned tasks	43.75
Students were waiting to get feedback on the assignments given	56.25
Take additional lessons	41.96
Do not take extra classes	58.04

The analysis of student's answers to the concepts studied shows that the ideas learned before midterm exam and final exam have a relationship with one another. For example, the concept of limiting reagents and composition percentage with the highest learning loss tends to be caused by students' lack of prior knowledge and the inability to relate one theory to another. As an example of solving limiting reagent problems, students must be able to solve all forms of chemical reaction problems, determine the reaction coefficient, calculate the moles, and determine the initial moles and the reacting moles. The pattern of student answers shows that the numeracy skills in using comparisons still need to improve. Making chemical reactions also indicates that students have difficulties in balancing reaction equations. Some students still need to improve in writing the molecular formula, which causes errors in the equation. In addition, when looking for moles of molecules, an error occurs when students cannot distinguish between atomic numbers and mass numbers. They need to understand that the nuclear mass number listed on the SPU is equivalent to the mass of 1 mole of atoms.

Several cases show that learning outcomes are more influenced by prior knowledge. Intelligence only provides an indirect effect (Thurn, Nussbaumer, Schumacher, & Stern, 2022). However, several factors can also affect learning opportunities, individual conditions, and the type of knowledge to be obtained (Simonsmeier, Flaig, Deiglmayr, Schalk, & Schneider, 2021). Prior knowledge becomes a determining factor for

student involvement in learning. Students who have high prior knowledge tend to seek study assistance. In contrast, students with low prior knowledge have no desire to seek study assistance (Dong, Jong, & King, 2020). This indication can be seen from the information from lecturers who teach introductory chemistry courses. On the other hand, students with high grades on assignments or quizzes (low learning loss) tend to be active in class and contact the lecturer if they need help understanding learning.

The relationship between the concepts tested shows that mastery of the idea of limiting reactants has a robust relationship with the knowledge of the concept of matter, properties of matter, mole and molar mass, percent composition, chemical reactions, empirical formulas, and molecular formulas ( $p < 0.000$ ). The concept of percent composition is the same, in contrast to the idea of a chemical reaction, which only strongly associates with the concept of a molecular formula. The images of moles and molar mass have a strong relationship with the empirical formula and the properties of matter ( $p < 0.000$ ).

Every basic concept of chemistry that is taught has a connection with one another based on student answer scores. The four images tested after the mid-semester show that the previous ideas strongly correlate with advanced concepts, as an example of determining the molecular formula. Students cannot answer this idea correctly if students do not master the concept of moles and molar masses, percent composition, chemical reactions, and empirical formulas. The importance of this prior knowledge is in line with the research of Wang, Fang, & Miao (2018), indicated by students' ability to construct concept maps as part of the understanding between concepts.

The high learning loss in chemistry concepts occurs more in the mastery of images that require numeracy skills in problem-solving. For example, limiting reagents requires students to understand the idea of comparison, which is part of numeracy skills. Research on chemistry learning has discussed the low interest in learning chemistry due to the difficulty of understanding chemical reactions (Timilsena, Maharjan, & Devkota, 2022). In addition, using mathematical aspects in problem-solving makes learning chemistry less attractive to students (Towns, Bain, & Rodriguez, 2019).

An indication of learning loss in chemical concepts is possible because the learning process was not optimal during COVID-19. The percentage of learning using the WA group, which is greater than learning using the Learning Management System (LMS), is likely a cause of learning loss. Following Alturki & Aldeaiweesh's research (2021), the use of LMS was more effective than the use of the WA group. This claim is because the features in the LMS are not only related to content but



connected to students' interactions with instructors and other students. Even so, the use of LMS can only partially replace direct learning. Students and teachers sometimes need to understand the use of features in the LMS. In addition, using online systems requires adaptation, support, and special skills in their service so that learning is optimal (Di Pietro et al., 2020). Therefore, analysis of the effect of changing learning methods needs to be studied regarding the causes of learning loss in chemical concepts.

The occurrence of COVID-19 within two years has caused the learning system to undergo significant changes. This affects the duration of students to learn chemistry concepts. Previous learning provides about 3 hours of student and teacher interaction in the learning process. During the pandemic, interactions were eliminated, and students only interacted virtually without even interacting with teachers. The results of the questionnaire analysis showed that students preferred 1-2 hours per week studying chemistry. According to Andrew et al. (2020), changes in learning duration are one of the factors causing learning loss, including chemistry. A higher learning period provides increased experience and skills for students (Díaz de León-López, Velázquez-Sánchez, Sánchez-Madrid, & Olais-Govea, 2021). If all this time students have been interacting for 3 hours directly, then reducing interaction time can cause their learning experience to decrease.

Some students responded by doing additional lessons to complete assignments given by the teacher during online learning. An in-depth study regarding the effect of extra tutoring needs to be carried out further. However, the results of this study indicated that students who previously attended additional lessons had a smaller percentage of learning loss compared to students who did not take extra classes. Therefore, it is suspected that there is a connection between the implementation of additional lessons and the duration of student learning, even though this study did not do so. According to Andrew et al. (2020), the average period for students to do schoolwork is 2.5 hours. This learning time duration indicates a more significant learning loss than previously thought (Green, 2020).

During online learning, students do not get feedback on their completed assignments. Even though feedback is the stage for the teacher to provide clarification and assess student performance, the results of the feedback can be used by the teacher as consideration for improving performance in the learning process. Therefore, online learning requires maximum feedback to enhance future understanding (Manole, 2021).

## Conclusion

The study results showed indications of learning loss in chemical concepts in the first-year FKIP, the University of Mataram students. Limiting reagent and percent composition shows the highest learning loss (53.57%), while the idea of moles and molar mass, and matter shows the lowest learning loss percentage of 32.14%. The results of statistical tests show the relationship between the average score before the midterm implementation and after the midterm implementation. An indication of learning loss is caused by the lack of online learning that was carried out previously to strengthen students' initial knowledge. This claim is reinforced by the questionnaire analysis, which illustrates that education is mainly done through WA groups, the duration of chemistry learning is low, and the lack of feedback given by the teacher on assignments that students are working on during the learning process.

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## Conflicts of Interest

There is no conflict of interest.

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