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REVEALING CHEMICAL MISCONCEPTIONS THROUGH THE MICROTEACHING PROCESS IN THE ERA OF THE COVID-19 PANDEMIC

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ABSTRACT

Unlimited access to information during the Covid-19 pandemic allows students with limited basic knowledge to experience misconceptions. Misconception happens because there are no adequate filters for many students, and there is no guarantee of content validity by information providers. This research aim is to show the misconceptions experienced by pre-service chemistry teachers. This research is a qualitative design with the case study method. This research used a naturalistic paradigm framework. The study was conducted for one semester of the 2020/2021 academic year for 16 meeting courses. The research participants consisted of pre-service chemistry teachers who were taking microteaching courses. Researchers are the main instrument. Data were collected through observation, focus group discussions (FGD), and document media analysis. The results showed six chemical misconceptions. Five misconceptions are non-proposition statements, and one is a chemical representation. Two of the six misconceptions found are resistant. Misconceptions that originate from written media and structured writing are difficult to overcome. Based on the study results, misconceptions about prerequisite concepts need to be eliminated before learning a new concept. Pre-service chemistry teachers need to use learning resources from the author's work according to their field of expertise. They have gone through the review and validation stages to avoid misconceptions.

***Keyword:** covid-19 pandemic; misconception; chemistry*

INTRODUCTION

Covid-19 has brought significant changes, especially in the implementation of learning. In an era of the Covid-19 pandemic, government policy has been set that the public must limit activities outside the home. Therefore, in the era of the covid-19 pandemic, generally, learning must be carried out far away, even though students are at home [1]. Therefore, online learning is unavoidable during the current COVID-19 pandemic. One of the courses that apply online learning is chemistry microteaching. The learning process takes place online using the peer teaching method and a video conference application. Students will take turns showing their basic teaching skills by being observed by other students and the facilitator.

Online learning gives students more significant opportunities to use online learning media. One of them is an online article that students can read every time. Anyone can write

articles on internet pages. Except for articles in scientific journals, generally, articles sourced on the internet are not guaranteed content validation from information providers. As a result, the article's content cannot be ensured that it is always correct and does not rule out the possibility of containing misconceptions. Several misconceptions experienced by students show that all of their misconceptions are parallel to the literature [2].

Misconceptions are more likely to occur in online learning if teachers do not control their students' understanding [3]. In addition, identifying students' misconceptions in large classes with online learning is more likely to be revealed because all students can be involved in unlimited group conversation media [4]. For example, 65% of chemistry students have misconceptions about the effect of pressure on the boiling point during the covid-19 pandemic [5].

Misconceptions can occur with unlimited active thinking opportunities but limited basic knowledge. Several undergraduate students who are pre-service chemistry teachers are aware of their little knowledge [6]. Limited basic knowledge indicates low thinking ability. Problem-based active learning cannot change students' misconceptions who have low levels of thinking [7]. Chemistry consists of many abstract concepts. A pre-service chemistry teacher who is still at the level of low thinking ability tends to have the potential to experience misconceptions.

The misconception is an understanding that someone has different from the concept whose scientific community [8, 9]. A person who experiences misconceptions thinks his interpretation is correct. Misconception can be identified with confident answers [10]. As a result, someone who experiences misconceptions is challenging to overcome. A particular strategy is needed to overcome this kind of misconception.

Misconceptions can potentially be experienced by anyone who has a concept or knowledge, including final year chemistry education students taking microteaching courses. This course is different from other courses in general. In the microteaching course, almost 90% is used for student teaching practice. The rest are questions, comments, and feedback from the course instructor. Pre-service chemistry teachers must meet several conditions before practicing basic teaching skills. These requirements are in the form of several preparatory tasks: a learning plan with attachments: evaluation instruments, practical guide, learning media (Powerpoint/ Ppt, teaching aids), learning resources (worksheet, knowledge statements), and Learning Scenarios. They prepared presented material, one of them in many statements/ representations that they believe are true (confidently statements). In preparing these assignments, students need references. Inappropriate reference selection and lack of knowledge about basic concepts cause students to display material that contains misconceptions. In addition, misconceptions also have the potential for students who only focus on preparing teaching techniques without paying attention to the chemical content. When practicing basic teaching skills, several pre-service chemistry teachers pay less attention to chemical misconceptions but focus more on teaching techniques [11].

The misconceptions experienced by final year students must be overcome. Addressing the misconception before they will carry out chemistry lessons during their internship at school or when they become teachers need to be done. Generally, student performance depends on the teacher's performance [12, 13], as it was found that it turns out that the misconceptions experienced by the teacher will be passed on to their students [14]. If not resolved, misconceptions persist and even recur for the same topic. The burden of misconceptions on each individual can be reduced [15]. Based on previous studies, the first step to avoid this misconception is to reveal the misconceptions experienced by pre-service chemistry teachers and then overcome them with particular methods.

Several previous researchers have reported several misconceptions experienced by pre-service chemistry teachers. For example, misconceptions about stereo-chemistry are experienced by pre-service chemistry teachers who are taking Basic Chemistry I and II courses at the University of Anatolia [2]. Furthermore, 147 out of 148 chemistry education students from various classes experienced misconceptions about particle matter [16]. Many pre-service chemistry teachers have misconceptions about the solution material [17]. Many pre-service chemistry teachers had misconceptions about radioactive decay material [18]. In another place, study results show misconceptions experienced by pre-service chemistry teachers on atomic orbital material [19]. It turns out that pre-service chemistry teachers have experienced several misconceptions on various topics for the last three years. This fact shows the urgency of efforts to uncover and overcome misconceptions in pre-service chemistry teachers at this time. Based on some previous research studies, there are still many misconceptions experienced by pre-service chemistry teachers that have not been revealed due to the misconceptions' nature (robust and repetitive), varied sources of misconceptions, and openness of information. Only confidently statements /answers can be judged as a correct concept or misconception based on the certainty of response index (CRI) method [10].

The essential teaching performance to uncover misconceptions is the skill of explaining. When pre-service chemistry teachers explain concepts, their understanding can be identified through the propositional statements and the chemical representations presented. Because everything delivered and presented has been prepared and believed correctly by the pre-service teachers, explanations, statements, and representations contradicting the scientific community's understanding can be stated as misconceptions.

Identifying misconceptions through analysis of propositional statements and chemical representations as confidently statements/representations is different from usual. In general, in identifying misconceptions, namely using diagnostic tests, for example, in the form of two-tier [20-22], three-tier forms [23-25], and four-tier forms [26][5]. A diagnostic test is based on the understanding that not all students' wrong answers or students can be classified as misconceptions. Based on the background of the problem above, research has been conducted to reveal the chemical misconceptions experienced by prospective

chemistry teacher students while attending microteaching lectures. The identified misconceptions were then investigated and validated through focus group discussions (FGD).

METHODS

1. **Research Design**

This study uses a qualitative design with the case study method. This research is naturalistic/constructive with an interpretive paradigm framework [27]. This naturalistic research was conducted in natural conditions (natural settings) to describe the misconceptions experienced by pre-service chemistry teachers who are taking microteaching courses. That means that microteaching classes are carried out naturally based on the Semester Lecture Design and the even semester lecture contract for the 2020/2021 academic year.

2. Research Subject

Ten pre-service chemistry teachers are taking microteaching courses as research informants. These ten students consist of two 5th-year students (RK, UM), one 4th-year student (IM), and seven 3rd-year students (AR, NR, NV, CM, US, RJ, AF).

3. Research Time

The research was conducted for one semester, namely the even semester of the 2020/2021 academic year. Students have observed their performance when practicing basic teaching skills for 16 meetings.

4. Research Instruments

This research is based on a qualitative method with the researcher as the main instrument. The first researcher has 13 years of experience as a lecturer staff in chemistry education studies and more than six years of experience as a microteaching course instructor. The second researcher has 28 years of experience as a lecturer staff for chemistry education and more than five years of experience as a microteaching teacher. The first researcher was present directly in 16 learning meetings. In addition, the first and second researchers conducted a content analysis of the results of observations, interviews (FGD), and documentation.

5. Procedure: Steps Revealing Misconception

Ten pre-service teachers were observed while practicing basic teaching skills. Basic teaching skills are divided into four stages, including:

(1) opening and closing skills of learning;

(2) the skills to explain concepts for specific topics;

(3) integrated skills; and

(4) teaching skills with the experimental method. Although there are four stages of practicing basic teaching skills, explaining is always done by students. So, each student has the opportunity to appear at least four times. Only two students got up to 5 times because of the remedial teaching practice. Participants are free to determine the topic of the material to be presented. During teaching practice, the researcher wrote down misconceptions and other errors experienced by students. The steps to reveal chemical misconceptions experienced by pre-service chemistry teachers are presented in Table 1.

Table 1. Steps Revealing Misconception

Steps Revealing Misconceptions	Each Step's Outcome
Cycle I: opening and closing skills of learning	
1. To observe the opening and closing skills of learning and match them with the lesson plan and scenario that was written for ten pre-service chemistry teachers	Misconception 1
2. Validation of the concept through FGD	Misconception change be correct concept
Cycle II: Concept Explaining Skill	
3. To observe concept explaining skills and match them with the lesson plan and scenario	Misconception 2-6
4. Validation of the concept through FGD	Misconception change be correct concept
Cycle III: Integrated teaching skills (from opening until closing)	
5. To observe integrated teaching skills and match them with the lesson plan and scenario	Misconceptions 3 and 4 repeatedly to the same pre-service chemistry teacher
6. Validation of the concept through FGD	Misconception change be correct concept
Cycle IV: Teaching Practice with experimental Method	
7. To observe teaching practice with experimental methods and match them with the practical guide that was written for ten pre-service chemistry teachers	There is no misconception.

After students practice basic teaching skills, FGD is immediately conducted to discover the source of misconceptions and carry out cognitive conflicts by asking several questions until concept validation is achieved. According to the lecture contract, when concept validation is achieved, the same student will practice the next basic skills for the next meeting

Documentation analysis is done by looking at the lesson plans and learning scenarios. Based on the document, the misconceptions presented in it have been identified.

6. Data Analysis

Qualitative data analyzed based on content analysis is part of the type of research in the interpretive paradigm framework [20]. Content analysis was carried out on the documentation, namely lesson plans, and scenarios. Direct observations were made during the practice of basic teaching skills. FGD involving all participants was carried out shortly after each student finished practicing basic teaching skills. After that, observations were made again for the next student.

7. Data Collection

The data was collected using observation and interviews (FGD) and documentation. Interviews were not conducted separately, but after observing the practice of teaching skills, if there were indications that students had misconceptions.

RESULTS AND DISCUSSION

1. Misconception Topics

The distribution of misconception topics that occur is shown in Table 2. Based

on Table 2. misconception occurs in 50% of topic of chemistry. These five chemistry topics are the fundamental concepts they have learned in introductory chemistry

Table 2. Misconceptions Occur in 5 of 10 Topics

No	Students	Topics Taught	Misconceptions (√) / No Misconceptions (×)
1	IM	Introduction to Chemistry	×
2	RK	Acid-base	√
3	US	Electrolyte Solution	√
4	AF	Chemical Bond	√
5	UM	Reaction rate	√
6	NR	Molecular Shape	×
7	NV	Thermochemistry	×
8	RJ	Atomic Structure	×
9	AR	Electron Configuration	√
10	CM	Hydrocarbon Compound	×

2. Misconceptions of Chemistry Hold Pre-service Chemistry Teachers

FGD after the students perform. At the time of the FGD, validation was carried out by the subject supervisor, in this case, the researcher. Based on the results of the FGD, it is known as the source of the misconception. Table 3. shows the distribution of misconceptions experienced by five students (50.0%).

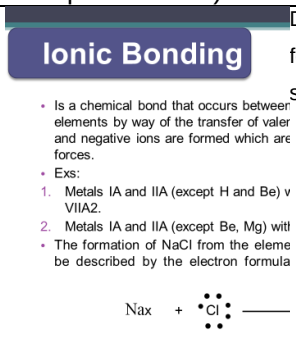
Table 3. Misconceptions Based on Observations and the Result of FGD

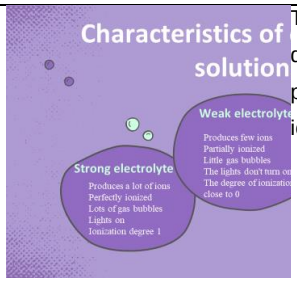
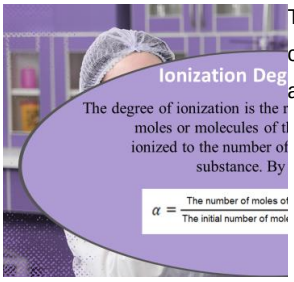
Meeting	Misconception Statement of Observation Results	FGD Results
1	Milk is an example of an acid (RK)	Milk is called acid because it contains lactic acid. Concept validation: Milk is a colloid consisting of a mixture of several substances.
4	Water as solvent must be more than solute (US)	So far, his understanding of water as a solvent Concept Validation: A solution with a mixed phase is the same, a matter that is more amount as solvent. However, if substances are mixed with a different phase, the solvent has maintained the phase even though a tiny amount.
	Ionization, when a substance decomposes into free ions in water (US)	Source of writing from the internet. Ionization is the dissolution of substances in water into free ions. Concept Validation: The decomposition of substances in water into ions can occur due to ionization and dissociation.

5	How to describe ionic bonds in Lewis's structure described covalently (AF)	Based on pictures from the internet. If the picture is like that, how do we know this is an ionic bond Concept Validation: His early history was Lewis structures for describing covalent compounds. For ionic compounds, negative and positive charges are added.
6	Catalyst does not react (UM)	Based on reading from the internet Concept Validation: Generally, the catalyst reacts with the reactants and, at the end of the reaction, is formed again
8	Each element has positive ions and negative ions. Al $^{3+}$, meaning Al has 3+ ions (AR)	Not mentioning the source, from understanding hisself. What does Al $^{3+}$ mean compared to Al Concept Validation: In general, metal elements form positive ions, whereas non-metallic elements form negative ions.
12	US has recurrent or resistant misconceptions	Same with the sixth meeting
13	AF has recurrent or resistant misconceptions	Same with the fifth meeting

The misconceptions that occur in each topic are followed up with In the Ppt document used by students when practicing integrated teaching skills, two misconceptions were found. The two misconceptions have occurred at the stage of explaining abilities. The following are the results of the lesson plan document (powerpoint) analysis.

Table 4. Misconceptions Hold Based on Analysis Results when Practicing Integrated Teaching Skills.

Pre-service Chemistry Teacher	Explanation (knowledge statement and representation)	Misconception	Correct Concept
AF		Depiction of the Lewis structure for NaCl is described by sharing a pair of electrons.	The Lewis structure's depiction for NaCl is described by the transfer and acceptance of electrons [28].

US		That everything that decomposes in water and produces free ions is called ionization.	That chemical decomposes in water and produces free ions are the result of ionization or dissociation [29].
		The above misconception continues α-degree referred to as the degree of ionization	α-degree referred to as the degree of ionization or dissociation [30]

Every student did not realize misconceptions and will know during the FGD. One of the objectives of the FGD is to make students aware of the misconceptions they have experienced. In the FGD, all participants were involved in giving each other comments and opinions until it was understood that the proposition presented by the student was not a valid concept. After the concept validation is achieved, the next student's performance is continued.

Based on Table 3 and Table 4. found six misconceptions experienced by five students of chemistry education who are taking microteaching courses. Five misconceptions are non-propositions, and one misconception is a symbolic represen-tation. The two misconceptions in Table 3 are document analysis results displayed when pre-service chemistry teachers practice basic teaching skills. These two misconceptions also occur when the student practices teaching skills in an integrated manner. Misconceptions that can be revealed occur on several topics, including; (1) acid-base; (2) reaction rate; (3) chemical bonds; (4) electrolyte solution and nonelectrolyte solution; and (5) electron configuration.

The six misconceptions above can be stated contrary to the understanding of the scientific community with the following explanation:

Misconception 1. Milk is an example of acid

Fresh milk is a nutritious liquid produced by mammals and humans, amphoteric [31]. Based on the size of the substance, milk is classified as a colloid, which means that milk is not a single substance. Instead, milk is a mixture of a dispersed substance and a dispersing agent. Fermentation in milk is done to extend shelf life. The fermentation process can increase the amino acids in milk [32]. Fermented milk, such as yogurt, contains lactic acid.

Misconceptions about the same topic have also been reported from the results of previous studies. As many as 12.7% of students have held the misconception that revamping the taste of milk and yogurt is only related to their physical properties change

[33]. In addition, most of the students hold misconceptions about acids and bases' characteristics [25].

Misconception 2. Water as solvent must be more than solute.

If solutes whose phase is the same as water, namely liquid, then water as a solvent must be more in number, for example, alcoholic beverages. This statement means that the amount of water is more than alcohol. However, if other substances are homogeneously mixed with water with different phases, the above statement cannot be entirely valid. For more clearly can be seen in Table 5.

Table 5. Solvent and Solute Phase

Solvent Phase	Solute Phase	Examples
		Solid Phase Solution
Solid	Solid	Brass Solvent: Copper(s) Solutes: Lead(s), tin(s), and zinc(s)
Solid	Liquid	Dental fillings Solvent: Silver(s) Solutes: Mercury(l) contain tin(s), and zinc(s)
Solid	Gas	Reduction Catalyst Solvent: Platinum(s) Solute: H2 molecule (g)
		Liquid Phase Solution
Liquid	Solid	Tincture of Iodine Solvent: Ethanol, $C_2H_5OH(l)$ Solute: Molecular Iodine(s)
Liquid	Liquid	Alcoholic beverages Solvent: water (l) Solute: Ethanol, $C_2H_5OH(l)$
Liquid	Gas	Carbonated Drinks Solvent: water (l) Solute: carbon dioxide (g)
		Gas Phase Solution
Gas	Solid	Aroma therapy Solvent: N_2 molecules (g) Solute: Camphor, $C_{10}H_{16}O(s)$
Gas	Liquid	Humid Air Solvent: N_2 molecule (g) Solute: water (l)
Gas	Gas	Air Solvent: N_2 (g) Solutes: molecule O_2 (g), CO_2 (g), and Ar (g)

Misconception 3. Ionization is when a substance decomposes into free ions in water

Students who experience this misconception cannot distinguish between dissociation and ionization. Misconceptions, for most students have experienced, are assumed that ionic compounds ionize in water [34]. Ionization is the process of dissolving covalent compounds into ions in water. Ionization is a process that produces one or more ions from neutral molecules [29]. The dissociation of ionic compounds (ion pairs) into free ions. Dissociation can also be interpreted as breaking large molecules into smaller molecules [35]. For example, HCl in water undergoes ionization, while NaCl in water undergoes dissociation.

Misconception 4. Drawing of Lewis structure of covalent, ionic bond

The representation presented by students below is a misconception because it does not show the presence of ionic bonds.

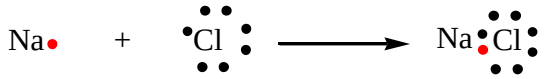


Figure 1. Lewis Structure of Ionic Bonds Described by Covalent Bonds by Students

The representation below does not fully show that NaCl is an ionic compound.

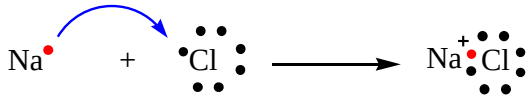


Figure 2. Lewis Structure of the Ionic Bond of NaCl Still Described Covalently. Source:

Figure 2. shows the presence of chemical bonds due to the sharing of electrons. The sharing of electrons is a characteristic of a covalent bond. For example, the representation that indicates that NaCl is an ionic compound is as follows.

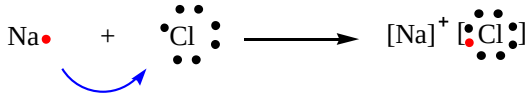


Figure 3. Lewis Structure of the NaCl Ionic Bond. Source:

Chemistry learning generally emphasizes macroscopic representations rather than submicroscopic and symbolic; as a result, students find it difficult to imagine the chemical reaction process and the structure of a substance [36]. Difficulty in understanding misconceptions can lead to misunderstanding. Consistent and convincing misconceptions indicate a chemical misconception.

Misconception 5. Catalysts don't react

A catalyst is a substance used to increase the rate of a reaction. Catalysts are referred to as reactants and products of a reaction [29]. The catalyst can participate in the reaction and eventually form again.

Misconception 6. Every element has positive ions and negative ions. For example, Al^{3+}, meaning Al has 3+ ions.

Students who experience the above misconceptions do not understand the difference between atoms, molecules, elements, and ions. Following are the definitions of atoms, molecules, elements, and ions. The smallest particle still characteristic of a chemical element is called an atom. A molecule is a neutral substance consisting of more than one atom. An element is a pure chemical substance consisting of atoms with the same protons number in the atomic nucleus [36]. For example, the element gold consists of gold atoms, all of which have the same number of protons in the atomic nucleus. Finally, ion is an atom or molecule that has an electric charge.

3. Sources of Misconceptions and Concept Validation Based on FGD

The misconception is a problem because it has varied sources [29,30]. Misconceptions are not realized by every student who experiences them; shortly after, the students that participate misconceptions. Furthermore, FGD was conducted to make students understand the misconceptions they had encountered. In the FGD, all participants were involved, giving each other comments and opinions until it was understood that the

proposition presented by the student was not a valid concept.

The questions asked by the researcher, for example, "is this statement (milk is an example of an acid compound) true?". Students who experienced misconceptions answered yes. The researcher's question continues, "why is milk acid? Where is the base from? or are your reasons?". Students who experience misconceptions answer because milk contains lactic acid. The researcher further asked, "what about fresh milk? Does it contain lactic acid?". Students begin to waver and experience cognitive conflicts.

Furthermore, the researcher explained to provide evidence that milk is not a single substance but a colloid so that there are known dispersed substances and dispersing media. This way is done to show that the milk is not acid. Furthermore, an explanation of the correct concept was delivered by the researcher.

The results of the FGDs are shown in Table 2. Several misconceptions are known to have no acid. Generally, students convey an understanding that they have held so far. It means that misconceptions come from misconceptions of prerequisite concepts. Only 2 out of 6 misconceptions mention the source from internet pages.

4. Resistant Misconceptions

Misconceptions 3 and 4, sourced from articles on internet pages, occur repeatedly and are experienced by the same students. Misconceptions occur at the explaining stage and the integrated teaching stage. It shows that 2 out of 6 misconceptions are resistant. It means that misconceptions reappear in students who remain after approximately two months of the concept validation process.

The two resistant misconceptions have in common: (1) they come from the same source, namely articles on internet pages: and (2) both are written in a structured way in the lesson plan. Based on these similarities, it can be stated that students' misconceptions that come from written media and have been written in a structured manner are difficult to change even though, through FGD in which, there is cognitive conflict conditioning. Cognitive conflict strategies are one way to reduce misconceptions[31 - 33].

5. Implications for Learning

Student reading sources need to be conditioned. It means that in the lesson plan, it is necessary to write that the sources that are used as references when practicing basic teaching skills include: (1) textbooks; (2) articles from scientific journals; (3) scientific research reports; and (4) writings from chemists on trusted websites or websites such as https://www.rsc.org/ by The Royal Society of Chemistry; https://www.acs.org/ by the American Chemistry Society; https://www.hki.or.id/ by the Indonesian chemical association; and https://chem.libretexts.org. According to his field of expertise, the four sources of reference above are the author's work and have gone through the review and validation stages. Thus, misconceptions or resistance can be prevented.

CONCLUSION

Misconceptions occur in five topics, namely acid-base, reaction rates, chemical

bonds, the concept of electron configuration prerequisites (atomic structure), and electrolyte solutions. Four of the six misconceptions can be reduced at the end of the lecture through FGDs, which involve cognitive conflicts. The four misconceptions come from misconceptions of prerequisite concepts. Two of the six misconceptions are resistant because pre-service chemistry teachers believe that all statemen or presentations come from written media and have been reported in structured writing was true. This condition causing misconception is difficult to change even though FGD in which there is cognitive conflict conditioning.

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