

DIAGNOSTIC TEST ON CHEMICAL EQUILIBRIUM MISCONCEPTION: A LITERATURE REVIEW

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Abstract: The abstract nature of chemical equilibrium learning material tend to result in misconception. The issues of misconception are identified using multi-tier diagnostic tests. This study aims to examine previous studies investigating the multi-tier diagnostic test in investigating the misconception of chemical equilibrium. We adopted a systematic literature review using the PRISMA method in analyzing 30 scientific articles discussing chemical equilibrium misconception and their analysis methods. The results of our content analysis suggest a number of multi-tier diagnostic test types that can be used to analyze the chemical equilibrium misconception, namely the two-tier, three-tier, and four-tier diagnostic tests.

Keywords: diagnostic test, chemical equilibrium, misconception

INTRODUCTION

Chemistry is a branch of science focusing on the materials' characteristics, structure, and change, along with the entailed energy. Aside from resolving calculations, chemistry also concerns conceptual problem-solving. Concepts are essential for a student. Students establish concepts from the ideas they extracted through their personal experiences and daily life. As each student experience a different reality, their established concepts also vary (Diani et al., 2019). Those students have the equal opportunity to construct the right or incorrect scientific concepts. Frequently, students attain incorrect conceptual understanding due to they observe differences between the theories they learned in school and reality (Yuberti et al., 2020).

This conceptual misunderstanding is commonly known as a misconception. The misconception is highly probable to occur during chemistry learning. One of the obligatory chemistry materials taught at the senior high school level is chemical equilibrium. In this material, students have to learn the concepts that they can and cannot evidently observe since it consists of many abstract concepts, such as the dynamic equilibrium, two-way reaction, and Le Chatelier principle (Jusniar et al., 2020). Students' comprehension of equilibrium theory is essential in helping them understand chemistry in-depth and as a whole. Besides, chemical equilibrium is also one of the fundamental concepts in chemistry required before learning the more complicated materials, such as acid-base, buffer solution, salt hydrolysis, redox, and electrochemistry (Sendur et al., 2010)

However, many senior high school students experience misconceptions during chemistry learning. A study by Indriani et al. (2017), involving 131 students in Bandung, Indonesia, reported the greatest mistake of 94% in the chemical equilibrium. Meanwhile, Monita & Suharto (2016) also

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recorded a similar finding that 58.61% of students in Banjarmasin, Indonesia, encounter misconceptions about chemical equilibrium material. Besides, the senior high school teachers from Central Java and Yogyakarta also position chemical equilibrium as the second material that induces the highest students misconception (Salirawati, 2011). An assessment instrument capable of diagnosing students' misconceptions is a misconception diagnostic instrument.

A diagnostic tool is a type of assessment instrument that identifies students' misconceptions (Gurel et al., 2015). This tool is frequently used by teachers to identify students' conceptual misconceptions, minimum knowledge, misunderstanding, and learning difficulties (Siswaningsih & Widasmar, 2019). Recently, the traditional multiple-choice diagnostic test has been modified into a multi-tier test that is claimed to have better abilities in discovering students' misconceptions or learning difficulties in more depth and detail. There are a number of diagnostic methods to see students' misconceptions, such as interviews, multiple choice test, open-ended test, and multi-tier test.

In this last decade (2010-2020), many studies have developed diagnostic instruments for chemistry materials, primarily for the chemical equilibrium material, providing the development method, along with their implementation in the learning process. However, different from other previous studies, this study used PRISMA literature analysis and relevant previous studies to identify the magnitude and progress of misconception in chemical equilibrium. Therefore, this study aims to 1) map the trend of diagnostic instruments for students' misconceptions in chemical equilibrium, 2) map the scientific publication on the misconception diagnostic instrument for chemical equilibrium material, and 3) outline different misconceptions on chemical equilibrium based on the previous studies.

METHOD

This systematic literature review used the PRISMA method. As illustrated in Figure 1, the procedures of this study consisted of 1) identification using the electronic search engine, 2) searching for relevant titles and abstracts while also eliminating the irrelevant ones, and 3) testing the feasibility by analyzing the articles and disqualifying the irrelevant articles. We involved a scientific article that discussed misconceptions about diagnostic test instruments for the chemical equilibrium material. The articles selection process was carried out using the Google Scholar search engine, focusing on the articles published in the last ten years, from October 2010 to October 2020. Additionally, we only used articles published by Indonesian journals indexed by SINTA, proceedings, and thesis. The last article finding was carried out on 28th October 2020.

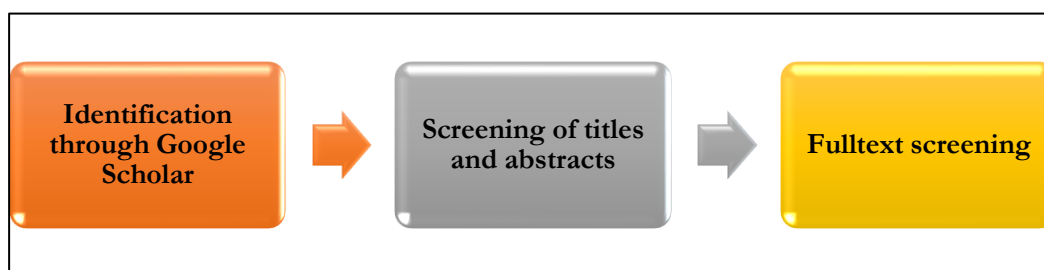


Figure 1. Procedures of Systematic Literature Review

The keywords we used in finding the articles included 1) chemical equilibrium misconception diagnostic and 2) misconception diagnostic about chemical equilibrium. From the first keyword, we gathered 653 articles, while from the second keyword, we obtained 1,430 articles. Further, we selected the first 200 relevant articles. As stated by Haddaway et al. (2015), to find the most pertinent literature, we should choose the first 200 to 300 articles from Google Scholar. Further, we evaluated the titles and abstracts from those 200 articles to determine the most relevant articles.

Later, we also assessed the full text of those articles. In the end, we selected the 30 most relevant articles for this study. The process of article elimination was carried out based on 1) their linkage to the chemical equilibrium misconception diagnostic test, 2) being published in Indonesian journals, and 3) being published in SINTA indexed journals.

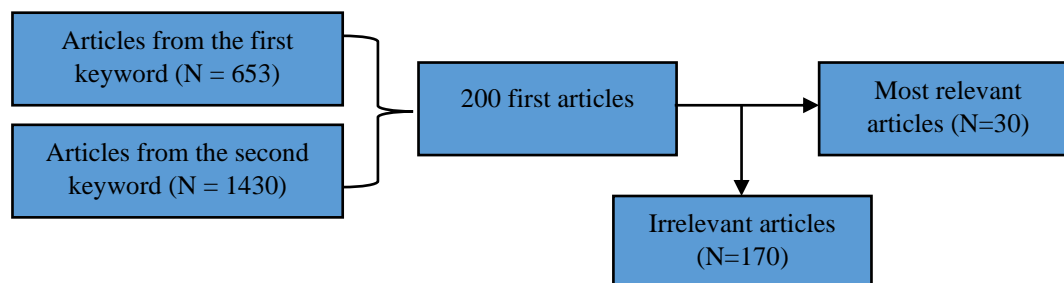


Figure 2. Analysis Process of Systematic Literature Review

RESULTS AND DISCUSSION

Chemical Equilibrium Misconception Diagnostic Test in the Last Decade

The results of a systematic literature review on 30 relevant scientific articles published between 2010-2020 suggest different diagnostic tests being used to find the students' misconceptions, as presented in Figure 3. Meanwhile, Figure 4 describes the use of those diagnostic tests each year.

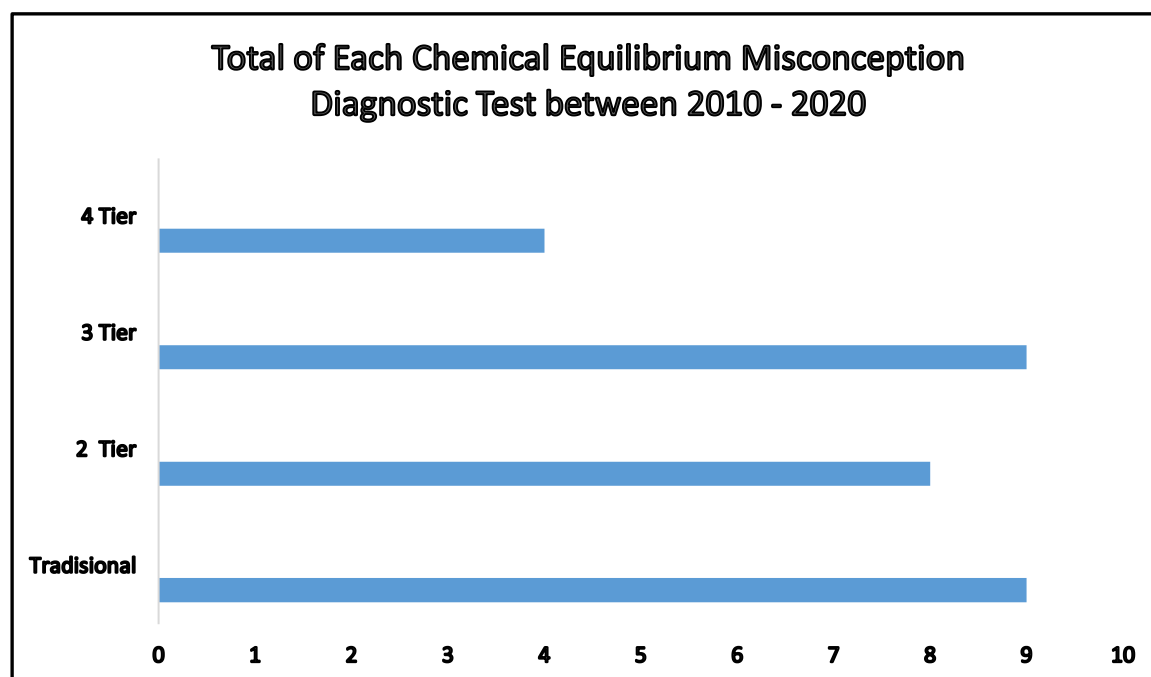


Figure 3. Number of Chemical Equilibrium Misconception Diagnostic Tests between 2010-2020

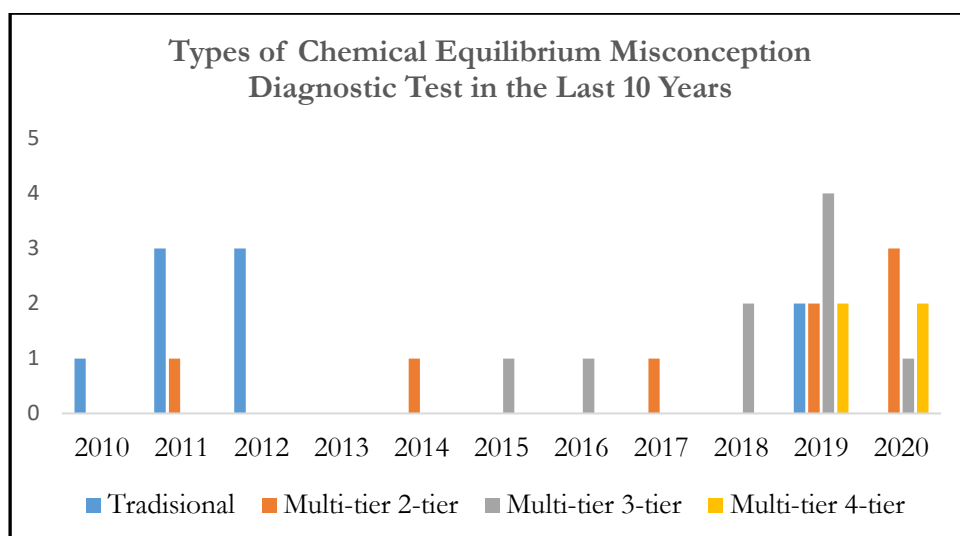


Figure 4. Types of Chemical Equilibrium Misconception Diagnostic Test in the Last 10 Years

The types of diagnostic tests used to identify students' misconceptions about chemical equilibrium material are progressing. In 2010, one article used a traditional test to diagnose students' misconceptions about chemical equilibrium material. Meanwhile, in 2011, three articles discussed the use of traditional tests, and one article used a two-tier test to diagnose students' misconceptions about chemical equilibrium. In 2012, three articles examined the use of the traditional diagnostic test, while in 2013, no research on the chemical equilibrium misconception diagnostic test was observed. Further, one article using the two-tier test and another article using the three-tier test were published in 2014 and 2015, respectively. Also, in 2016, there was only one article examined a three-tier diagnostic test to identify students' misconceptions about chemical equilibrium. In 2017 and 2018, four articles, two for each year, used three-tier diagnostic tests. Comparatively, in 2019, there were two articles using the traditional test, while two others used a two-tier diagnostic test, and four and two studies used three-tier and four-tier diagnostic tests, respectively. In 2020, there were three, one, and two research articles discussing the two-tier, three-tier, and four-tier diagnostic tests for chemical equilibrium misconception, respectively. Therefore, in the last ten years, there were nine research articles examining traditional diagnostic tests, eight articles investigated the two-tier diagnostic test, while 9 and 4 of them discussed the three-tier and four-tier diagnostic tests, respectively, for students' misconception of chemical equilibrium material.

Publication Types of Articles Investigating Chemical Equilibrium Misconception Diagnostic Test in The Last 10 Years

The 30 scientific articles on chemical equilibrium misconception, gathered from Google Scholar and published between 2010-2020, were categorized based on their types of publication. The categorization consisted of journals indexed by SINTA and Google Scholar. The result of publication mapping is illustrated in Figure 5.

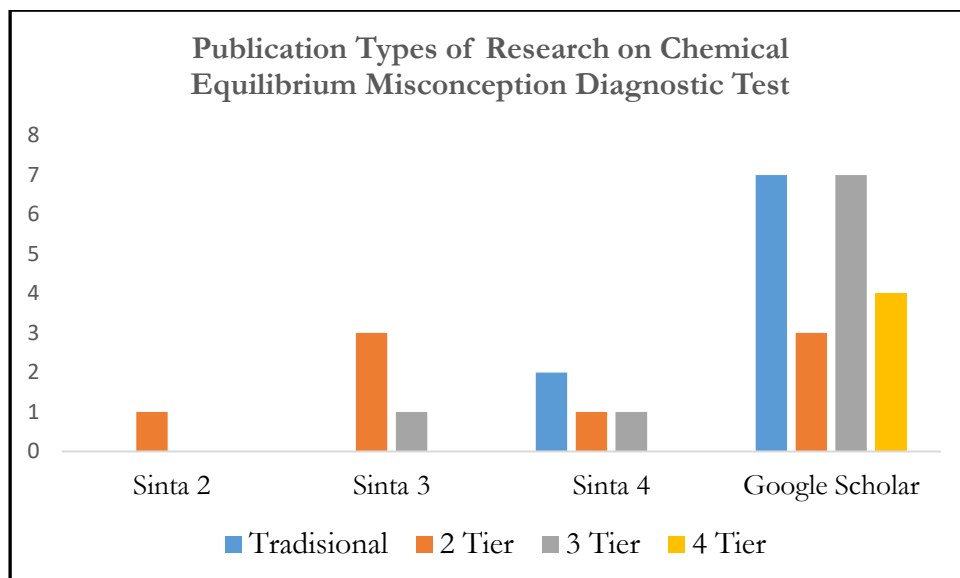


Figure 5. Publication Types of Research on Chemical Equilibrium Misconception Diagnostic Test

There was one article using a two-tier diagnostic test published in the journal indexed in SINTA 2. In the SINTA 3 journals, there were three and one articles discussing the two-tier and three-tier diagnostic tests, respectively. Meanwhile, in the SINTA 4 journals, there were two articles examining traditional diagnostic tests, as well as one article on the two-tier and three-tier diagnostic tests. From the Google Scholar indexed journals, there were seven articles discussing the traditional diagnostic test, three research on the two-tier test, as well as seven and four articles investigating the three-tier and four-tier diagnostic tests.

Identification of Chemical Equilibrium Misconception in the Last 10 Years

According to our systematic analysis results of the relevant studies, students' chemical equilibrium misconceptions on each type of diagnostic instrument are presented in Table 1.

Table 1. Identification of Chemical Equilibrium Misconception

Type of Instruments	Authors	Identified Misconception
two-tier	(Antari et al., 2020; Harahap, 2014; Indriani et al., 2017; Salirawati, 2011; Satriana, 2019; Sidauruk & Damsyik, 2020; Timanoyo et al., 2020; Usu et al., 2019)	<ul style="list-style-type: none"> ➤ Students presumed that a state of equilibrium is attained once the concentration of reactant is equal to product concentration, and the reaction will be stopped. ➤ In the topic of equilibrium shifts factors, students presume that an increase of pressure shifts the reaction into the substance with a higher mol. ➤ Students assume that the equilibrium shifts to the substance with a higher coefficient once the reaction pressure is enhanced. ➤ Students consider the direct involvement of the catalyst in the reaction, affecting the shift of equilibrium. ➤ Students regard that the addition of catalysts in the reaction causes the shift of the reaction into the product.
three-tier	(Akbar dkk., t.t.; Anzila, 2019; HASRAT, 2015; Laksono, 2020; Monita & Suharto, 2016; Sitompul, 2018; Wahyuni, 2019; Widasmara, 2018)	<ul style="list-style-type: none"> ➤ Students remain to present high misconceptions about the sub-concept of dynamic equilibrium. They presume that a state of equilibrium is attained if the mass of the reactant is equal to the mass of the product. ➤ Students consider if the volume of the solution in the reaction is exothermic, then the equilibrium shifts to the product. ➤ In a reaction, if the volume is increased, the rate of reaction will increase, and the equilibrium shifts to the product. ➤ Students presume the net value of equilibrium will change if the equilibrium in the reaction shifts. ➤ Many students assume that in a shift of equilibrium, the net value also changes.
four-tier	(Agustin, 2020; Dewi, 2019; Tsabitah, t.t.; Winata, 2019)	<ul style="list-style-type: none"> ➤ Students presume that a state of equilibrium is obtained if the concentration of reactant is equal to the concentration of the product. ➤ Siswa masih mengalami kesulitan dalam menentukan zat manakah yang terlibat dalam perhitungan nilai tetapan kesetimbangan ➤ Students encounter misconceptions in the sub-concept of equilibrium shift. They presume the catalyst can shift the equilibrium as the catalyst accelerate the reaction rate.

Each type of multi-tier test offers different features. The differences between the three types of diagnostic tests are presented in table 2.

Table 2. Differences between Each Type of Multi-Tier Diagnostic Tests

Differentiating Factors	<i>Two-tier</i>	<i>Three-tier</i>	<i>Four-tier</i>
Components	Tier 1: primary question and the answer options Tier 2: options of reason	Tier 1: primary question and the answer options Tier 2: options of reason Tier 3: the scale of confidence for the selected answer and reason	Tier 1: primary question and the answer options Tier 2: the scale of confidence for the selected answer Tier 3: options of reason Tier 4: the scale of confidence for the selected reason
Advantage	Can categorize the students who have the correct understanding and misconception	<ul style="list-style-type: none"> ● Present scale of confidence, enabling us to differentiate students who genuinely have the answer from those who are just guessing the answer ● Can categorize students into students who understand the concept, have a misconception, and do not understand the concept at all 	<ul style="list-style-type: none"> ● Offer two scales of confidence, enabling students to express their different levels of confidence in selecting the answer and reason ● Can categorize the students' level of understanding and misconception
Weakness	Unable to identify students' confidence in their answer	Unable to locate students' different confidence levels in selecting their answers and reason	Require a longer time

CONCLUSIONS

The results of our content analysis showed that the common multi-tier diagnostic test used to identify the students' misconceptions on chemical equilibrium is the two-tier, three-tier, and four-tier diagnostic tests. In the last ten years, the most commonly used diagnostic tests in the chemical equilibrium misconception are traditional, two-tier, and three-tier diagnostic tests.

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