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DIAGNOSING STUDENTS' MISCONCEPTIONS IN CHEMICAL EQUILIBRIUM THROUGH A THREE-TIER MULTIPLE CHOICE APPROACH

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ABSTRAK

Penelitian ini bertujuan mengidentifikasi miskonsepsi siswa pada materi kesetimbangan kimia menggunakan instrumen *Three-Tier Multiple Choice* (TTMC) serta menganalisisnya berdasarkan *multiple chemical representations*. Penelitian menggunakan pendekatan deskriptif kuantitatif dengan subjek 78 siswa kelas XI SMAN 1 Pringgarata yang dipilih menggunakan teknik sampling jenuh. Instrumen penelitian berupa tes TTMC yang terdiri atas tiga tingkat, yaitu jawaban, alasan, dan tingkat keyakinan, sehingga mampu mengidentifikasi pemahaman konseptual siswa secara mendalam. Data dianalisis secara deskriptif kuantitatif. Hasil penelitian menunjukkan bahwa persentase miskonsepsi pada setiap indikator berkisar antara 32,05%–48,07%, dengan persentase miskonsepsi keseluruhan sebesar 42% yang termasuk kategori sedang. Berdasarkan analisis *multiple chemical representations*, miskonsepsi tertinggi ditemukan pada representasi makroskopik (44,2%), diikuti oleh representasi simbolik (43,6%), dan submikroskopik (37,2%). Temuan ini menunjukkan bahwa siswa masih mengalami kesulitan mengintegrasikan fenomena makroskopik, mekanisme partikel pada tingkat submikroskopik, dan representasi simbolik dalam memahami konsep kesetimbangan kimia. Instrumen TTMC efektif digunakan sebagai alat diagnostik untuk mengidentifikasi karakteristik miskonsepsi siswa dan dapat menjadi dasar dalam merancang pembelajaran kimia yang mengintegrasikan ketiga representasi tersebut.

ABSTRACT

This study aimed to identify students' misconceptions about chemical equilibrium using the Three Tier Multiple Choice (TTMC) diagnostic instrument and to analyze them based on multiple chemical representations. A quantitative descriptive design was employed involving 78 eleventh-grade students of SMAN 1 Pringgarata selected through total sampling. The research instrument was a TTMC test consisting of three tiers: answer, reason, and confidence level, enabling a more accurate diagnosis of students' conceptual understanding. Data were analyzed using descriptive quantitative methods. The results revealed that misconceptions across the assessed indicators ranged from 32.05% to 48.07%, with an overall misconception rate of 42%, categorized as moderate. Based on the analysis of multiple chemical representations, the highest misconception occurred in the macroscopic representation (44.2%), followed by the symbolic representation (43.6%) and the submicroscopic representation (37.2%). These findings indicate that students still experience difficulties integrating macroscopic phenomena, submicroscopic particle behavior, and symbolic representations when understanding chemical equilibrium concepts. The TTMC instrument proved effective for diagnosing students' misconceptions and can serve as a basis for designing chemistry instruction that explicitly integrates the three levels of chemical representation.

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INTRODUCTION

Chemistry learning in high school plays a crucial role in shaping students' scientific thinking skills, particularly their ability to understand abstract and complex concepts. Chemistry, as a multidimensional science, requires students to connect real phenomena with processes that cannot be directly observed and to represent them symbolically (Moju et al., 2025; Zhang & Jiang, 2026). In chemistry education, this ability is known as multiple chemical representations (MCR), which consist of macroscopic, submicroscopic, and symbolic representations. Macroscopic representations relate to directly observable phenomena; submicroscopic representations explain the behavior of particles such as atoms, ions, and molecules that cannot be directly observed; and symbolic representations are used to express concepts through reaction equations, chemical formulas, graphs, and mathematical calculations. These three representations are complementary, so a complete understanding of chemical concepts can only be formed if students are able to connect all three simultaneously (Johnstone, 1991; Gilbert & Treagust, 2009; Talanquer, 2011; Taber, 2013). The inability to translate between representations causes students to tend to understand concepts partially, making them more susceptible to misconceptions. One topic that reflects this complexity is chemical equilibrium, which requires an understanding of the dynamic relationship between forward and reverse reactions and their connection to mathematical concepts such as the equilibrium constant. Therefore, learning chemical equilibrium relies not only on memorization but also on in-depth conceptual skills to integrate various scientific representations holistically (Febriana & Sukarmin, 2025).

Students' inability to develop in-depth conceptual understanding often leads to misconceptions. Misconceptions are forms of understanding that are inconsistent with actual scientific concepts and are relatively stable because they have been internalized in students' cognitive structures. Misconceptions are not only caused by cognitive factors but are also influenced by students' preconceptions, the teaching strategies used by teachers, and the learning context, including the school environment, local culture, and learning media (Saputri et al., 2022; Subayani & Nugroho, 2019). Furthermore, contextual factors such as students' academic backgrounds and school characteristics also play a role in forming and maintaining misconceptions. Therefore, selecting an appropriate learning model is crucial, as it has been shown to significantly reduce misconceptions (Listyani et al., 2024).

The complexity of the concept of chemical equilibrium increases because this material requires students to simultaneously integrate macroscopic, submicroscopic, and symbolic representations. At the macroscopic level, students observe changes in color, concentration, and visible reaction conditions. At the submicroscopic level, students must understand that equilibrium occurs because the rates of forward and reverse reactions are equal due to the dynamic, ongoing collisions of particles. Furthermore, at the symbolic level, students need to connect these phenomena to reaction equations, equilibrium constant expressions (Kc and Kp), reaction quotients (Q), and various associated mathematical relationships. Difficulties in translating information between levels of representation cause students to develop incomplete understanding, leading to various misconceptions (Golestaneh & Mousavi, 2024; Laohapornchaiphan & Chenprakhon, 2024). This leads to various misconceptions, such as the assumption that equilibrium is static, a misunderstanding of Le Chatelier's principle, and an inaccurate distinction between the equilibrium constant (K) and the reaction quotient (Q) (Gültepe, 2021; Hagos & Andargie, 2022; Rahmawati et al., 2022; Widhiyanti et al., 2022).

These misconceptions are systematic and do not arise randomly, but rather stem from inaccurate knowledge construction, particularly in connecting macroscopic, submicroscopic, and symbolic representations (Golestaneh & Mousavi, 2024; Peperkorn et al., 2024). Therefore, efforts to accurately identify misconceptions are necessary to design appropriate learning interventions. However, the process of identifying misconceptions also faces methodological challenges. Conventional assessment instruments, such as multiple-choice questions, are unable to clearly distinguish between students who truly understand a concept, those who don't, and those who answer correctly by guessing.

Various studies have shown that most misconceptions about chemical equilibrium stem from students' failure to connect symbolic representations with submicroscopic representations. For example, students are able to write the equilibrium constant equation mathematically but fail to understand that changes in K and Q values result from changes in the number of particles at the molecular level. Similarly, many students consider equilibrium to be the state in which a reaction has stopped because they focus solely on the symbolic representation rather than understanding the dynamics of particle collisions at the submicroscopic level. Consequently, problem-solving is often performed procedurally without being supported by a proper conceptual understanding (Treagust & Chandrasegaran, 2009; Taber, 2013; Gültepe, 2021).

In response to the limitations of conventional instruments, multilevel diagnostic instruments have been developed, including the Three-Tier Multiple Choice (TTMC). The first tier assesses the conceptual accuracy of the answer, the second tier evaluates the scientific reasoning behind it, and the third tier measures the student's confidence in their answer. The combination of these three tiers allows researchers to differentiate among students who truly understand the concept, those who do not yet understand it, those who guess the answer, and those who hold misconceptions with a high level of confidence. Thus, the existence of confidence levels is an important aspect because correct answers do not necessarily indicate conceptual understanding if given with a low level of confidence, while incorrect answers accompanied by high confidence indicate misconceptions that are deeply rooted in students' cognitive structures (Pesman & Eryilmaz, 2010; Gurel et al., 2015; Nisa et al., 2024; Ruth et al., 2025).

Although various studies have identified misconceptions in chemical equilibrium, most studies still focus on the percentage of misconceptions without linking them to students' failure to integrate macroscopic, submicroscopic, and symbolic representations. Furthermore, the use of TTMC in many studies is primarily focused on identifying correct and incorrect answers, while analyses that combine answers, reasons, and confidence levels to reveal students' conceptual structures remain relatively limited. Therefore, this study not only maps students' misconceptions in chemical equilibrium but also analyzes how these misconceptions relate to the failure to connect various chemical representations using the TTMC instrument.

This study aims to identify students' misconceptions regarding chemical equilibrium using the Three-Tier Multiple-Choice instrument at SMAN 1 Pringgarata. This research is expected to not only provide empirical contributions to mapping student misconceptions in the local context, but also strengthen the use of diagnostic instruments in chemistry education research and serve as a basis for developing more effective, evidence-based learning interventions (evidence-based instruction). In line with these objectives, this study examines whether the Three-Tier Multiple-Choice instrument can identify student misconceptions in chemical equilibrium material more accurately and comprehensively than conventional evaluation approaches.

METHOD

This research is a quantitative descriptive study with a non-experimental design that is diagnostic in nature (Creswell & Creswell, 2018). The aim is to identify students' misconceptions about chemical equilibrium material. The research was conducted at SMAN 1 Pringgarata with 78 research subjects who were determined using a saturated sampling technique, namely a sampling technique involving all members of the population as samples (Sugiyono, 2019). The instrument used was a Three-Tier Multiple Choice (TTMC) diagnostic test consisting of 15 multiple-choice questions, consisting of three levels, namely answer choices, reasons, and student confidence levels, with the choice of sure or not sure, so as to be able to identify misconceptions more accurately (Nisa et al., 2024; Ruth et al., 2025). The instrument was first validated by 4 Chemistry Lecturers as validators. The validation results were calculated using Aiken's V, with an average of 0.87, indicating the instrument is considered very valid. This research did not involve treatment, but the researcher only collected data directly at the research location. Data collection was conducted by administering the TTMC test to students, then analyzing the data using descriptive quantitative analysis. Data analysis was performed by calculating student answer scores and grouping the results into the following categories:

Table 1. TTMC answer categories

Tier 1	Tier 2	Tier 3	Kategori
Correct	Correct	Certain	Complete Understanding (PU)
Correct	False	Certain	Positive Misconceptions (MP)
False	Correct	Certain	Negative Misconceptions(MN)
False	False	Certain	Misconceptions (M)
Correct	Correct	Not Certain	Lucky guess/lack of confidence (TB/KPD)
Correct	False	Not Certain	Lack of Knowledge (KP)
False	Correct	Not Certain	Lack of Knowledge (KP)
False	False	Not Certain	Lack of Knowledge (KP)

(Source: S.Mubarak and Yahdi, 2020)

The categories of misconceptions obtained can be seen in Table 2 below.

Table 2. Misconception criteria

Percentage of misconceptions	Misconception criteria
0 < Misconception ≤ 30%	Low
30 < Misconception ≤ 70%	Moderate
70 < Misconception ≤ 100%	High

(Source: Kurniawan Y and A Suhandi, 2014)

The percentage is obtained from comparing the number of students who got the misconception category (MP, MN, and M) with the total number of students, then expressed as a percentage.

RESULT AND DISCUSSION

The instrument used to identify misconceptions in chemical equilibrium is designed to represent the three characteristics of chemistry. The following is an explanation of each question:

Table 3: Classification of questions based on dominant representation

No.	Concept/Indicator	Macro	Submicro	Symbolic	Dominant Representation	Basis of Classification
1	Dynamic equilibrium	✓	✓	–	Submicroscopic	Understanding reaction dynamics at the particle level.

No.	Concept/Indicator	Macro	Submicro	Symbolic	Dominant Representation	Basis of Classification
2	Dynamic equilibrium	✓	✓	–	Submicroscopic	Explains the equilibrium process at the particle level.
3	Homogeneous–heterogeneous equilibrium	–	–	✓	Symbolic	Based on the reaction equation and phase symbols.
4	Kc Form	–	–	✓	Symbolic	Constructing equilibrium constant expressions.
5	Kc Calculation	–	–	✓	Symbolic	Mathematical manipulation of the Kc equation.
6	Kp Form	–	–	✓	Symbolic	Determine the pressure constant expression.
7	Kp Calculation	–	–	✓	Symbolic	Calculation of partial pressure constant.
8	Kc–Kp Relationship	–	–	✓	Symbolic	Using the mathematical relationship Kc and Kp.
9	Kc–Kp Calculation	–	–	✓	Symbolic	Substitute the Kc–Kp equation.
10	Degree of dissociation	–	✓	✓	Symbolic	Relate calculations to the number of particles.
11	Degree of dissociation	–	✓	✓	Symbolic	The concept of particles underlies the calculations.
12	Le Chatelier's Principle	✓	✓	✓	Submicroscopic	Relate changes in conditions to particle responses.
13	Le Chatelier's Principle	✓	✓	✓	Submicroscopic	Explain the mechanism of equilibrium shift.
14	Industrial chemical production	✓	✓	✓	Macroscopic	Based on industrial phenomena and applications.
15	Industrial chemical production	✓	✓	✓	Macroscopic	Based on macroscopic phenomena in industry.

Thus, a summary of the number of questions based on their dominant representation can be seen in Table 4.

Table 4. Questions based on dominant representation

Dominant Representation	Item Number	Number of Questions
Makroskopik	14, 15	2
Submikroskopik	1, 2, 12, 13	4
Simbolik	3, 4, 5, 6, 7, 8, 9, 10, 11	9

The mapping results indicate that most TTMC items are oriented toward symbolic representation. This aligns with the characteristics of chemical equilibrium material, which frequently involves reaction equations, equilibrium constants, and mathematical calculations.

Based on students' answers on the three-tier multiple-choice diagnostic test, descriptions of the TTMC answer categories and misconceptions are shown in Tables 5 and 6.

Table 5. Description of students' TTMC answer categories

No	Categories	Average Percentage (%)
1	Complete Understanding (PU)	27.01
2	Positive Misconceptions (MP)	12.39
3	Negative Misconceptions(MN)	9.5
4	Misconceptions (M)	20.43
5	Lucky guess/lack of confidence (TB/KPD)	6.92
6	Lack of Knowledge (KP)	24.10

Table 6. Categories of student misconceptions

Misconception criteria	Number of students	Percentage (%)
Low	29	37.18
Moderate	39	50,00
High	10	12,82
Total	78	100

Misconceptions for each indicator and chemical representation are shown in Table 7. The TTMC answer results for each question item are shown in Table 8.

Table 7. Student misconceptions for each indicator and representation

Subject	Item Number	Misconceptions (%)	Average	Categories
Explaining the meaning of dynamic equilibrium	1	32.05	32.05	moderate
Explaining the meaning of equilibrium.	2	39.74	39.1	moderate
Differentiating between homogeneous and heterogeneous equilibrium and examples of dynamic equilibrium.	3	38.46		
Determining the concentration constant	4	38.46	42.9	moderate
	5	47.44		
Determining partial pressure (Kp) in equilibrium	6	46.15	39.1	moderate
	7	32.05		
Connecting Kc and Kp prices	8	50	48.0	moderate
	9	46.15		
Explaining the value of the degree of dissociation	10	42.31	46.8	moderate
	11	51.28		
Estimating the direction of equilibrium shift using Le Chatelier's principle	12	33.33	41.45	moderate
	13	43.59		
	14	47.44		
Explains the production of industrial chemicals based on equilibrium reactions.	15	41.03	41.03	moderate
Yellow color (submicroscopic misconception)			37.2%	moderate
Blue color (symbolic misconception)			43.6%	moderate
Green color (macroscopic misconception)			44.2%	moderate

Table 8. Description of the TTMC answer results for each question item

Subject	Representation	Item Number	PU (%)	MP (%)	MN (%)	M (%)	TB/KPD (%)	KP (%)
Explaining the meaning of dynamic equilibrium	Submicroscopic	1	51	7.7	3.8	21	3.8	13

Subject	Representation	Item Number	PU (%)	MP (%)	MN (%)	M (%)	TB/KPD (%)	KP (%)
Distinguishing between homogeneous and heterogeneous equilibrium and examples		2	43.6	12.82	12.82	14.1	7.69	8.97
Estimating the direction of equilibrium shift using Le Chatelier's principle		12	24	3.8	7.7	22	12	31
		13	28.2	15.4	8.97	19.2	6.41	21.8
Distinguishing between homogeneous and heterogeneous equilibrium and examples	Symbolic	3	37	10	8	21	8	17
Determining the concentration constant		4	28	15	6.4	17	14	19
		5	17	18	10	19	9	27
Determining partial pressure (Kp) in equilibrium		6	23	12	14	19	10	21
		7	24	6.4	3.8	22	0	44
Connecting Kc and Kp values		8	22	14	13	23	1.3	27
		9	19	12	7.7	27	5.1	29
Explaining the value of the degree of dissociation		10	12	14	5.1	23	2.6	44
		11	32.1	15.4	12.8	23.1	3.85	12.8
Estimating the direction of equilibrium shift using Le Chatelier's principle	Macroscopic	14	21	19	10	18	7.7	24
Explains the production of industrial chemicals based on equilibrium reactions.		15	23.1	8.97	12.8	19.2	12.8	23.1

Based on Table 8, in the complete understanding category, the highest indicator was the concept of dynamic equilibrium, with 51% of the students (40). Meanwhile, the lowest indicator was the degree of dissociation (12%), with 9 students. In the positive misconception category, the highest indicator was the concept of estimating the direction of equilibrium shift based on Le Chatelier's principle (19%), with 15 students. Meanwhile, the lowest indicator was the concept of determining partial pressure (Kp) at equilibrium (6.4%), with 5 students. In the negative misconception category, the highest indicator was the concept of determining partial pressure (Kp) at equilibrium (14%), with 11 students. Meanwhile, the lowest indicator was the concept of explaining dynamic equilibrium (3.8%), with 3 students.

In the misconception category, the highest indicator was the concept of connecting the values of Kc and Kp (27%), with 21 students. Meanwhile, the lowest indicator was the concept of distinguishing homogeneous and heterogeneous equilibrium, along with examples, at 14%, consisting of 11 students. In the lucky-guess/lack-of-confidence category, the highest indicator was the concept of determining the concentration constant (Kc), at 14%, with 11 students. Meanwhile, the lowest indicator was the concept of determining partial pressure (Kp) at equilibrium, at 0%. In the lack of knowledge category, the highest indicators were the concept of determining partial pressure (Kp) at equilibrium and the concept of explaining the degree of dissociation of an equilibrium reaction, at 44%, consisting of 34 students. Meanwhile, the lowest indicator was the concept of distinguishing homogeneous and heterogeneous equilibrium, along with examples, at 8.9%, consisting of 7 students.

The results of the study indicate that students' level of understanding of chemical equilibrium is still relatively low. This is evident from the percentage of complete understanding (27.01%), which remains lower than the combined categories of misconception and lack of knowledge. This finding indicates that most students have not been able to develop a complete conceptual understanding of the concept of chemical equilibrium. This condition aligns with the characteristics of chemistry as a science that demands the integration of macroscopic, submicroscopic, and symbolic phenomena. Therefore, if any one level is not properly understood, it will lead to conceptual errors (Becker et al., 2015; Seliwati, 2018; Sukmawati, 2019).

In general, the distribution of misconception categories shows that the majority of students fall into the moderate misconception category (50%), followed by low (37.18%) and high (12.82%) categories. This pattern indicates that misconceptions are not extreme, but are evenly distributed across various levels of student understanding. This finding confirms that misconceptions are systematic and do not arise randomly, but rather result from inaccurate knowledge construction (Laeli et al., 2023; Lestari et al., 2025). Furthermore, the presence of moderate misconceptions indicates that students have some correct understanding but are not yet consistent in applying these concepts.

Based on the results for each indicator, all chemical equilibrium concepts fall into the moderate misconception category, with percentages ranging from 32.05% to 48.0%. This indicates that students' difficulties are not focused solely on one particular concept but are comprehensive. The concept with the highest level of misconception is connecting Kc and Kp values (48.0%), followed by the degree of dissociation (46.8%) and the equilibrium constant (42.9%). The high level of misconceptions in these concepts indicates that students experience difficulties in the symbolic and mathematical aspects, particularly in interpreting the relationships between variables in an equilibrium system. This is in line with previous research, which stated that students often experience difficulties in understanding the relationship between K and Q and the transformation between Kc and Kp because it involves mathematical abstraction (Permatasari et al., 2022; Pongkendek & Kristyasari, 2022).

The concept that students relatively understood best was dynamic equilibrium (32.05%), although it still fell into the moderate misconception category. The high percentage of complete understanding of this concept (51%) indicates that students more easily understand phenomena that can be linked to macroscopic representations. However, misconceptions persisted regarding this concept, particularly regarding the understanding that equilibrium is static, not dynamic. This finding is consistent with the literature indicating that students tend to view equilibrium as a state in which a reaction stops, rather than as a dynamic state in which forward and reverse reactions proceed at equal rates (Pongkendek & Kristyasari, 2022; Prasetya, 2025).

Further analysis of each TTMC category revealed that the lack of knowledge category (24.10%) was also quite high, particularly for the concepts of partial pressure (Kp) and degree of dissociation (44%). This indicates that some students lacked sufficient knowledge to answer the questions, resulting not only in misconceptions but also in conceptual ignorance. This situation suggests that students' difficulties stem not only from conceptual errors but also from a lack of fundamental mastery of the material. According to previous research, a lack of basic knowledge is often the primary cause of misconceptions, as students construct new concepts based on incomplete understanding (Rohmah & Priyono, 2023).

The presence of both positive and negative misconceptions indicates that students hold incorrect answers or are inconsistent in their understanding of concepts. The relatively high number of positive misconceptions regarding Le Chatelier's principle (19%) indicates that students tend to believe in incorrect understandings, particularly in predicting the direction of equilibrium shifts. This aligns with research indicating that Le Chatelier's principle is a major source of misconceptions, as students often rely on intuitive reasoning that is inconsistent with scientific concepts (Permatasari et al., 2022; Ramadhani & Nada, 2023).

To obtain a more comprehensive picture of students' misconception characteristics, the identification results were analyzed not only on material indicators but also on the chemical representations measured by each TTMC item. Based on the instrument's content analysis, nine items focused on symbolic representations, four on submicroscopic representations, and two on macroscopic representations. This grouping refers to the concept of multiple chemical representations, which emphasizes that understanding of chemical concepts is built through the relationship between macroscopic, submicroscopic, and symbolic representations so that these three representations need to be integrated in the learning and assessment process (Chenprakhon, 2024).

Analysis based on chemical representations shows that macroscopic representations have the highest percentage of misconceptions (44.2%), followed by symbolic representations (43.6%), while submicroscopic representations show the lowest percentage (37.2%). Although all three are in the moderate category, the difference between macroscopic and symbolic representations is relatively small, indicating that students experience difficulties with both representations almost equally. The high level of misconceptions in macroscopic representations indicates that students have been unable to interpret observed chemical equilibrium phenomena, such as how changes in concentration, pressure, or temperature affect equilibrium shifts in real contexts. Meanwhile, the high level of misconceptions about symbolic representations indicates that students still encounter obstacles in understanding reaction equations, equilibrium constants (Kc and Kp), and the mathematical relationships used to explain equilibrium phenomena. These findings indicate that students are unable to fully connect observed phenomena with particle mechanisms and symbolic representations, resulting in incomplete conceptual understanding (Permatasari, Rahayu, & Dasna, 2022; Alqadri & Munawwarah, 2025; Munawwarah & Ashari, 2025).

These findings are reinforced by analyses of several TTMC items. In the equilibrium constant (Kc) indicator, for example, students are asked to determine the expression for the equilibrium constant based on the reaction equation. This question is considered a symbolic representation because it requires the ability to connect reaction coefficients with the mathematical form of the Kc equation. The analysis shows that many students still incorrectly construct the equilibrium constant expression, indicating a tendency to memorize formulas rather than understand the underlying stoichiometry of the reaction. In the Le Chatelier principle indicator, the question relates changes in macroscopic conditions, such as changes in concentration or pressure, to changes in the number of particles at the submicroscopic level. Some students provided correct answers but provided inappropriate reasons, or conversely, expressed high confidence in their incorrect answers. These conditions indicate that misconceptions occur not only in the use of reaction symbols, but also in understanding the particle mechanisms that cause a system to reach a new equilibrium. These findings align with research stating that failure to connect macroscopic, submicroscopic, and symbolic representations is a major cause of misconceptions in chemistry learning (Golestaneh & Mousavi, 2024; Laohapornchaiphan & Chenprakhon, 2024; Sukmawati, 2019).

Based on these findings, it is understood that misconceptions in chemical equilibrium are not only caused by errors in using symbols or completing calculations, but also by students' failure to fully integrate all three levels of chemical representation. Therefore, learning needs to be designed to explicitly connect macroscopic phenomena, particle-level process visualizations, and symbolic representations through models, visual media, and simulations. Furthermore, the use of diagnostic instruments such as the TTMC has been shown to identify misconceptions more effectively, thereby providing a basis for designing more targeted learning interventions to improve students' conceptual understanding.

CONCLUSION

This study successfully identified students' misconceptions about chemical equilibrium using the Three-Tier Multiple-Choice (TTMC) instrument. The results showed that 42% of students experienced moderate misconceptions. Based on the analysis of multiple chemical representations, the highest number of misconceptions was found in macroscopic representations (44.2%), followed by symbolic representations (43.6%) and submicroscopic representations (37.2%), indicating that students still had difficulty integrating observed phenomena, particle mechanisms, and symbolic representations as a whole. These findings confirm that TTMC can be used as a diagnostic instrument to identify the characteristics of students' misconceptions and can be a basis for designing chemistry learning that integrates all three levels of representation to improve students' conceptual understanding.

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