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The Effectiveness of The Six Tier Diagnostic Test (STDT) Instrument in Viewed from Empirical Validity to Identify Student's Misconceptions in Chemical Equilibrium Materials

Suyono[1*], Khurrotul Aini[2], I Gusti Made Sanjaya[3]
[1,2,3] State University of Surabaya, Surabaya, Indonesia

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ABSTRACT
Objective: Students are said to understand the concept comprehensively if they master the concepts from dimensions of ontology, epistemology, and axiology. One of the topics that still needs to be clarified is chemical equilibrium. Therefore, it is necessary to develop instruments to diagnose conceptions about the chemical concepts taught. The STDT is one of the instruments that will be developed by researchers, which contains three scientific questions to identify misconceptions in chemical equilibrium. **Method:** This development research used the ADDIE model. The instrument's effectiveness refers to the empirical validity after applying the STDT instrument. The effectiveness of the STDT instrument was obtained through the correlation of misconceptions experienced by students with the level of difficulty of the items. The STDT instrument was applied to 86 students. **Results:** The percentage of students who experienced the highest misconceptions occurred in the chemical equilibrium section of the equilibrium shift due to the influence of a catalyst. In each item of questions, most students need more knowledge or knowledge. The composition of the difficulty of these items should be considered from the start of the instrument's preparation. In the developed STDT instrument, the item difficulty obtained from empirical trials on students did not meet the ideal conditions for the composition of the item difficulty level. **Novelty:** The resulting instrument for detecting misconceptions. It is a tier diagnostic test that is integrated with three scientific questions.

INTRODUCTION

Teaching chemistry as a branch of science to students should refer to a philosophical foundation in the development of science, which includes three scientific components: scientific product, scientific method, and scientific attitude. The chemical content taught is a scientific product that includes facts, concepts, principles, laws, and theories. In addition to paying attention to scientific products, planning and implementing chemistry lessons must include the scientific method and a scientific attitude (Istikhomah & Wachid, 2021). Students are stated to be able to master the concept comprehensively if they can answer three scientific questions related to the concept being studied. The three scientific questions are ontology, epistemology, and axiology. Ontology, epistemology, and axiology questions are marked with the keywords what, how, and what are the benefits, respectively.

The concept is defined as a generalization of facts with the same characteristics. The concept is abstract because it does not have its existence other than in the individual's mental representation. The results of generalizing (abstraction) facts that have been accommodated in one's schema are called conceptions (Wahyuni, 2018). Conception is a person's perspective on a concept. Suppose the results of an individual's abstraction of a concept are not by the scientific understanding or understanding received by scientists in the field concerned. In that case, this individual is declared to have a misconception (Yuliati, 2017). If learning chemistry concepts facilitates the process of constructing knowledge and organizing information into students' cognitive structures in a comprehensive manner, then the possibility of misconceptions can be minimized (Rosita et al., 2020; Şen, & Yilmaz, 2017).

Students have a comprehensive conception of chemistry; correctly viewed from the dimensions of ontology, epistemology, and axiology, it can be determined as an achievement of chemistry learning. It is necessary to develop instruments to diagnose conceptions or misconceptions about the chemical concepts that have been learned. Through this instrument, it will be determined whether a person has a misconception or not on certain chemical concepts. To determine whether someone has a misconception or not, a representative instrument is needed. Representation of the dimensions of ontology, epistemology, and axiology in the package of questions on mastering chemistry concepts becomes urgent when one wants to take a comprehensive picture of one's conception. Diagnostic tests determine weaknesses in students' understanding of a concept (Anam, 2019; Prodjosantoso, 2019). An excellent diagnostic test can provide an accurate picture of the misconceptions experienced by students based on the error information they make (Bayuni, 2018; Maharani, 2019; Qonita & Ermawati, 2020). Good diagnostic questions not only show that students do not understand certain parts of the material but can also show how students think in answering the questions given, even though the answers are not correct (Setiawan, 2020; Sari, 2020; Timothy, 2023). Suppose this statement is linked to three scientific questions. In that case, an excellent diagnostic question will not only show that students do not understand the ontology dimension but also how students think about how concepts are constructed (epistemology) and the benefits or values of a concept (axiology). Therefore, it is necessary to develop instruments to measure students' conceptual understanding of the three scientific questions.

The development of research on diagnostic tests has reached the five-tier diagnostic test. However, the diagnostic test instrument has yet to reach the level of understanding of the use value (axiological aspect) of the concept. In analyzing the depth of concepts measured by the instrument, the instrument still only measures concepts in the ontology aspect. Based on this, it is necessary to improve the development of diagnostic test instruments into six-tier diagnostic tests, which can measure students' understanding of concepts comprehensively. Further development of existing diagnostic test instruments is needed. The diagnostic test instrument that was developed next was the six-tier diagnostic test, referred to as the STDT instrument. The STDT instrument developed is capable of analyzing students' conceptual understanding comprehensively from aspects of ontology, epistemology, to axiology.

The STDT instrument format is multiple-choice questions with five answer choices in the first, third, and fifth tiers. The first tier is in the form of questions on the ontology aspect, the third tier is a question on the epistemological aspect, and the fifth tier is a question on the axiological aspect. In addition to the multiple choice questions, the STDT instrument also contains confidence questions for the level of student answers located in the second, fourth, and sixth tiers. Confidence level questions are presented as a certainty of response index (CRI), which contains students' confidence levels on a scale of 0 to 5 (Borovicza & Szarka, 2023).

Several studies have shown that chemical equilibrium is an essential topic in the study of chemistry learning but is difficult to understand (Mai, 2021). Usu (2019), Siswaningsih (2019), and Harza (2021) argued that students often experience misconceptions about chemical equilibrium, especially in the dynamic equilibrium subtopic. Siswaningsih (2017), Jusniar (2019), Yamtinah (2019), Khairunnisa & Prodjosantoso (2020), Andriani, et al., (2020), and Jusniar (2020) suggested that apart from dynamic equilibrium, misconceptions about chemical equilibrium also occur in the sub-topics of equilibrium shifts and equilibrium constants. The research results regarding misconceptions about other chemical equilibriums developed by Omilani and Elebute (2020) suggest that misconceptions about chemical equilibrium material also occur in the sub-topic of factors that influence shifts in equilibrium. Based on several research results, it was concluded that there are still things that need to be clarified about chemical equilibrium material. Identification of misconceptions must use instruments that can measure students' understanding of concepts in a representative way. In this article, we will discuss the empirical validity of the STDT instruments that have been developed.

RESEARCH METHOD

This type of research is Research and Development (R&D). Development research is a method used to produce specific products and to test the effectiveness of these products (Sugiono, 2017). The development of the SMA chemistry STDT instrument refers to the ADDIE development model. The ADDIE model consists of five stages, namely analysis and evaluation, design and evaluation, development and evaluation, implementation and evaluation, and evaluation (Branch, 2009).

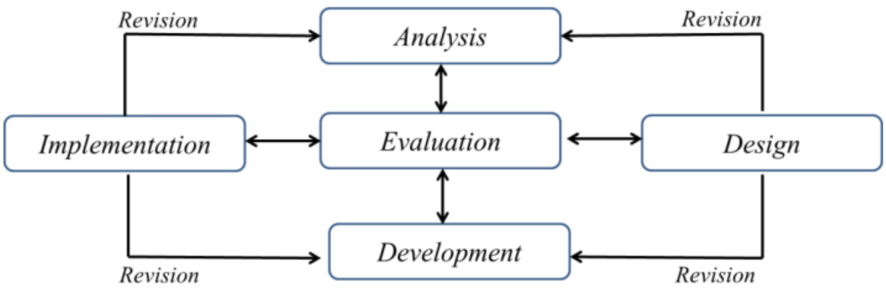

Figure 1. Flowchart of ADDIE model development (Branch, 2009).

The STDT instrument developed was implemented on a sample of 86 students from a total population of 108 students at Hang Tuah 5 Sidoarjo Senior High School. The results of instrument implementation are used to analyze the reliability and effectiveness of the instrument, which refers to empirical validity. The reliability of the instrument was analyzed using the Cronbach's Alpha method. The effectiveness of the instrument is tested by correlating the distribution pattern of the level of misconceptions with the design level of ease or level of difficulty of the questions. The distribution pattern of student misconception levels was obtained from the results of data analysis after students were tested using the STDT instrument. After carrying out the instrument test, data was obtained on the percentage of students who experienced misconceptions. Data on the percentage of students who experience misconceptions is then categorized into three intervals, high, medium, and low, for each question item. The level of ease and difficulty of the questions is obtained by analyzing the percentage of students' correct answers, which are then categorized into easy, medium, and challenging questions. Data on the level of misconceptions and difficulty of questions were then tested using chi-square statistical analysis.

RESULTS AND DISCUSSION

Results

Type of Conception

The application of the STDT instrument measures the level of students' conceptions. Determination of the category of students' conception level is determined based on various possible student answers at all levels of questions by the rubric of the instrument. Based on the analysis of students' answers, categorizing the level of students' conceptions was carried out. Table 1 shows the students' proposed conception levels in the six-tier diagnostic test format.

Table 1. Description of student's conception level in the six-tier diagnostic test instrument.

Conception Level	Description
SC (Scientific Conception)	Respondents gave all correct answers on the ontology, epistemology, and axiology aspects of the concept. Overall, confidence levels were high in answering all three aspects of the question.
LC (Lack of Confidence)	Respondents gave all correct answers on the ontology, epistemology, and axiology aspects of the concept. There is at least one answer with a low confidence level in one aspect of the question.
LK (Lack of Knowledge)	Respondents gave at least one correct answer to questions regarding aspects of ontology, epistemology, and axiology of concepts. There is at least one answer with a low confidence level in one aspect of the question.
MSC (Misconception)	Respondents gave all wrong answers on the ontology, epistemology, and axiology aspects of the concept. Overall, confidence levels were high in answering all three aspects of the question.
HNC (Have No Conception)	Respondents gave all wrong answers on the ontology, epistemology, and axiology aspects of the concept. All confidence levels are low in answering all three aspects of the question.

Conception level data will then focus on data on the percentage of students who experience misconceptions about each item. This is done to determine the instrument's effectiveness through the empirical validity of the results of students' answers. Data on the percentage of students who experience misconceptions will be tested using chi-squared with the difficulty level of the items. Before that, the data on the percentage of students who experienced misconceptions were categorized into small, medium, and large numbers with the same data range intervals.

Table 2. Number of students' misconceptions on each question item.

Question Item	Number of Misconceptions (%)	Category	Question Item	Number of Misconceptions (%)	Category
1	2.25	Less	9	11.24	Medium
2	5.62	Less	10	7.87	Less
3	8.99	Less	11	13.48	Medium
4	3.37	Less	12	7.87	Less
5	5.62	Less	13	26.97	More
6	6.74	Less	14	12.36	Medium
7	10.11	Medium	15	6.74	Less
8	6.74	Less			

Based on Table 2, there are ten questions with a low percentage of students having misconceptions, four with a moderate percentage of students experiencing misconceptions, and 1 question with a problematic percentage of students experiencing misconceptions.

Relationship Students' Misconceptions and Difficulty Level of Question Items

The application of the STDT instrument is also used to analyze the level of difficulty of the instrument questions. The difficulty level of a question item is the proportion of students who answer correctly. The more significant the *p*-value (difficulty level index) of a question, the easier the problem is. Conversely, the smaller the *p*-value (difficulty level index), the more complex the item is. The difficulty index data for each item on the STDT instrument is presented in Table 3.

Table 3. Question item difficulty index.

Question Item	Difficulty Level Index (*p*)	Category	Question Item	Difficulty Level Index (*p*)	Category
1	0,63	Middle	9	0,34	Middle
2	0,42	Middle	10	0,33	Middle
3	0,36	Middle	11	0,27	Difficult
4	0,57	Middle	12	0,41	Middle
5	0,59	Middle	13	0,15	Difficult
6	0,47	Middle	14	0,31	Middle
7	0,34	Middle	15	0,33	Middle
8	0,39	Middle			

The results of testing the data on the percentage of students who experience misconceptions about the difficulty of the 15 items on the STDT instrument are presented in Tables 4 and 5. Based on the data in Table 4, the number of questions at the medium difficulty level is 13 questions, and at the complex level is two questions. The percentage of students who have a little misconception at the difficulty level of easy questions does not exist; at the medium difficulty level, there are ten questions, and there are no complicated questions. The percentage of students with moderate misconceptions at the difficulty level of easy questions did not exist; at the medium difficulty level, there were three questions, and at the difficulty level for complex questions, 1. The percentage of students with many misconceptions at the easy problem level did not exist, medium difficulty level did not exist, and difficult item difficulty level 1.

Table 4. Crossing data on the percentage of misconceptions with problem difficulties.

		Degree of Difficulty		Total
		Medium	Difficult	
Percentage of MSC	Less	10	0	10
	Medium	3	1	4
	More	0	1	1
Total		13	2	15

Table 5. Chi-square tests.

	Value	df	Asymp. Sig. (2-sided)

Pearson Chi-Square	8.510a	0.014
Likelihood Ratio	7.282	0.026
Linear-by-Linear Association	6.981	0.008
Nof Valid Cases	15	

Based on the data from the chi-square test results above, the Asymp value is obtained. Sig. (2-sided) 0.014. Referring to the basis for decision-making previously described, the Asymp. Sig. (2-sided) 0.014 <0.05, it can be concluded that H0 is rejected and Ha is accepted. This shows a relationship between the difficulty of the items and the percentage of students who experience misconceptions. These results indicate the instrument's effectiveness in terms of the empirical validity of the results of the application of the STDT instrument.

To support the instrument effectiveness data, which refers to empirical validity data, the instrument reliability data is also analyzed. Reliability testing can be used to determine the consistency of a measuring instrument and whether the measuring instrument remains consistent if the measurement is repeated. A measuring instrument is reliable if it produces the same results, even if measurements are taken many times. The results of the reliability test using Cronbach's Alpha method produced an instrument reliability coefficient (r) of 0.815. The rtable value used for N=86 or df=N-2 is df=84 with a significance level of 5% or 0.05, namely 0.212. With these results, the test instrument that has been developed is reliable because r count > r table.

Discussion

After the implementation of the instrument test, data on the level of students' conceptions was obtained, which was then narrowed down to focus on the percentage of students who had misconceptions. Data on the percentage of students who experience misconceptions are then categorized into three intervals, namely high, medium, and low, for each item. The level of difficulty of the questions is obtained from an analysis of the percentage of correctness of student answers, which are then also categorized into easy, medium, and challenging questions. Data on the level of misconceptions and difficulty of the questions were then tested using chi-square statistical analysis.

The STDT instrument was developed to measure the level of students' conceptions, especially to detect students' misconceptions. The results of the application of the instrument showed that there were students who needed clarification about each item. The results of the highest misconceptions were found in item number 13, with the number of students experiencing misconceptions at 26.97%. This percentage value will be the highest reference for students who experience misconceptions. Three ranges of values will be made from 0 to 26.97%, which will then be given the few, medium, and many categories. Of the 15 questions on the STDT instrument that were developed, ten questions were in the category of the number of students who experienced slight misconceptions, four questions were in the category of the number of students who experienced moderate misconceptions, and 1 item in the category of the number of students who experienced a large number of misconceptions.

Other data obtained is data on the difficulty of the items, which are categorized as easy, medium, and challenging questions. The categorization of questions in the STDT instrument refers to the analysis of empirical data on the percentage of correctness of student answers (Haeruddin et al., 2020; Karunia & Ridlo, 2022; Wuryandani & Herwin, 2021). Based on the analysis of student answers, there were 13 questions in the moderate category and two in the problematic category. There were no questions in the easy category; 86.67% of the questions were in the medium category, and 13.33% were in the difficult category. The composition of the item difficulty level in a package of questions ideally consists of 25.00% easy questions, 50.00% medium questions, and 25% difficult questions (Rahmi et al., 2022). Initially, the preparation of the test items on the STDT instrument only paid attention to the focus on the indicators of instrument development; namely, the items contained aspects of ontology, epistemology, and axiology comprehensively. The composition of the difficulty level of the test items had yet to be considered at the beginning of the preparation of the items on the STDT instrument. This needs to be a concern in preparing the next question package.

Data on the number of students who experienced misconceptions and data on the level of difficulty of each item were then correlated with the chi-square statistical test. The chi-square test helps test the relationship or influence of two variables and measuring the strength of the relationship between one variable and another (Djarwanto, 1985). In this study, the strength of the relationship was tested for two variables, namely the level of difficulty of the items and the number of students who had misconceptions about each item. The chi-square test that has been done shows that H0 is rejected and Ha is accepted. This can be interpreted if there is a relationship between the difficulty of the items and misconceptions. Based on the results of these statistical tests, it can be concluded that the effectiveness of the instrument has been fulfilled (Artyushkova, 2020; Hoekstra et al., 2019; Lindner et al., 2020; Van Smeden et al., 2020). The instrument can identify misconceptions experienced by students based on the distribution of difficulty levels of the items developed. The discussion regarding the validity, practicality, and effectiveness of the above instruments refers to a conclusion that the developed STDT instrument meets the valid, practical, and effective criteria. The STDT instrument is feasible to measure students' conceptions, especially in detecting misconceptions. Of course, the level of conceptions, especially misconceptions that are detected, is comprehensively measurable in terms of three scientific questions, namely ontology, epistemology, and axiology.

CONCLUSION

Fundamental Finding: A valid six-tier diagnostic test instrument was produced to detect students' misconceptions about chemical equilibrium material. **Implication:** STDT can be used by teachers to detect students' conceptions of chemical equilibrium material and become a reference for other researchers to develop similar research. **Limitation:** The STDT that has been developed integrates three scientific questions, where the three scientific questions are benchmarks of comprehensive understanding. **Future Research:** STDT can be developed to diagnose students' types of conceptions in other materials.

REFERENCES

Anam, R. S., Widodo, A., Sopandi, W., & Wu, H.-K. (2019). Developing a five-tier diagnostic test to identify students' misconceptions in science: An example of the heat transfer concepts. *İlköğretim Online 18 (3)*, 1014-1029. https://doi.org/10.17051/ilkonline.2019.609690

Andriani, Y., Mulyani, S., & Wiji, W. (2021). Misconceptions and troublesome knowledge on chemical equilibrium. *Journal of Physics: Conference Series*, 1-6. https://doi.org/10.1088/1742-6596/1806/1/012184

Artyushkova, K. (2020). Misconceptions in interpretation of nitrogen chemistry from x-ray photoelectron spectra. *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films*, *38*(3). https://doi.org/10.1116/1.5135923

Bayuni, T., Sopandi, W., & Sujana, A. (2018). Identification misconception of primary school teacher education students in changes of matters using a five-tier diagnostic test. *Journal of Physics: Conference Series, 1013*, 1-8. https://doi.org/10.1088/1742-6596/1013/1/012086

Borovicza, B., & Szarka, K. (2023) A review of diagnostic assessment tools used in studies to uncover the misconceptions in science education, *INTED 2023 Proceedings*, 967-973.

Branch, R. M. (2009). *Instructional design the ADDIE approach*. Univercity of Georgia.

Djarwanto, D. (1985). *Statistik nonparametris*. BPFE.

Haeruddin, Prasetyo, Z. K., & Supahar. (2020). The development of a metacognition instrument for college students to solve physics problems. *International Journal of Instruction*, *13*(1), 767–782. https://doi.org/10.29333/iji.2020.13149a

Harza, A., Wiji, W., & Mulyani, S. (2021). Potency to overcome misconceptions by using multiple representations on the concept of chemical equilibrium. *Journal of Physics: Conference Series, 1806*, 1-6. https://doi.org/10.1088/1742-6596/1806/1/012197

Hoekstra, R., Vugteveen, J., Warrens, M. J., & Kruyen, P. M. (2019). An empirical analysis of alleged misunderstandings of coefficient alpha. *International Journal of Social Research Methodology*, *22*(4), 351–364. https://doi.org/10.1080/13645579.2018.1547523

Istikhomah, R. I., & Wachid, A. (2021). Filsafat sebagai landasan ilmu dalam pengembangan sains. *Jurnal Filsafat Indonesia, 4*(1), 60-64.

Jusniar, J., Effendi, E., Budiasih, E., & Sutrisno, S. (2019). The misconception of stoichiometry and its impact on the chemical equilibrium. *Advances in Social Science, Education and Humanities Research (ASSEHR), 227*, 138-141. https://doi.org/10.2991/icamr-18.2019.35

Jusniar, J., Effendy, E., Budiasih, E., & Sutrisno, S. (2020). Misconceptions in rate of reaction and their impact on misconceptions in chemical equilibrium. *European Journal of Educational Research, 9*(4), 1405 - 1423.

Karunia, R., & Ridlo, S. (2022). STEM integrated flipped classroom learning tools on biodiversity materials to improve students' critical thinking skills. *Journal of Biology Education*, *11*(2), 242–253.

Khairunnisa, K., & Prodjosantoso, A. (2020). Analysis of students misconception in chemical equilibrium. *JTK: Jurnal Tadris Kimiya 5,* 71-79. https://doi.org/10.12973/eu-jer.9.4.1405

Lindner, T., Puck, J., & Verbeke, A. (2020). Misconceptions about multicollinearity in international business research: Identification, consequences, and remedies. *Journal of International Business Studies*, *51*(3), 283–298. https://doi.org/10.1057/s41267-019-00257-1

Maharani, L., Rahayu, D. I., Amaliah, E., Rahayu, R., & Saregar, A. (2019). Diagnostic test with four-tier in physics learning: Case of misconception in newton's law material. *Journal of Physics: Conference Series*, *1155*, 1-8. https://doi.org/10.1088/1742-6596/1155/1/012022

Mai, Y., Qian, Y., Li, L., & Lan, H. (2021). The conceptual structure of chemical equilibrium inupper-secondary school students: Evidence from factor analysis. *Journal of Baltic Science Education, 20,*(1), 80-92. http://dx.doi.org/10.33225/jbse/21.20.80

Omilani, N., & Elebute, F. (2020). Analysis of misconceptions in chemical equilibrium among senior secondary school students in ilesa metropolis in osun state, nigeria. *African Journal of Educational Studies in Mathematics and Sciences, 16*(2), 1-13. https://dx.doi.org/10.4314/ajesms.v16i.2.1

Prodjosantoso, A. K., Hertina, A. M., & Irwanto, I. (2019). The misconception diagnosis on ionic and covalent bonds concepts with three tier diagnostic test. *International Journal of Instruction, 12(1)*, 1477-1488. http://dx.doi.org/10.29333/iji.2019.12194a

Qonita, M., & Ermawati, F. (2020). The validity and reliability of five-tier conception diagnostic test for vector concepts. *Inovasi Pendidikan Fisika, 9,*(3), 459-465. https://doi.org/10.26740/ipf.v9n3.p459-465

Rahmi, R., Kustati, M., & Hadeli, H. (2022). *Evaluasi pendidikan perspektif islam.* Penerbit Deepublish.

Rosita, I., Liliawati, W., & Samsudin, A. (2020). Pengembangan instrumen five-tier newton's laws test (5TNLT) untuk mengidentifikasi miskonsepsi dan penyebab miskonsepsi siswa. *Jurnal Pendidikan Fisika dan Teknologi (JPFT), 6*(2), 297-306. http://dx.doi.org/10.29303/jpft.v6i2.2018

Sari, D. R., Sopandi, W., Surtikanti, H. K., & Arviana, R. (2018). Analysis of primary school students' misconception through six tier diagnostic test about the concept of water characteristics. *Jurnal Dimensi Pendidikan dan Pembelajaran, 6*(3), 112-118.

Şen, Ş., & Yilmaz, A. (2017). The development of a three-tier chemical bonding concept test. *Journal of Turkish Science Education, 14*(1), 110-126. http://dx.doi.org/10.12973/tused.10193a

Setiawan, D. (2020). *Pengembangan asesmen diagnostik miskonsepsi fluida berformat five-tier untuk mengungkap profil pemahaman konsep siswa*. Thesis. Universitas Negeri Semarang.

Siswaningsih, W., Firman, H., Zackiyah, & Khoirunnisa, A. (2017). Development of two-tier diagnostic test pictorial-based for identifying high school students misconceptions on the mole concept. *Journal of Physics: Conference Series, 1812,* 1-7. https://doi.org/10.1088/1742-6596/812/1/012117

Siswaningsih, W., Nahadi, N., & Widasmara, R. (2019). Development of three tier multiple choice diagnostic test to assess students' misconception of chemical equilibrium. *Journal of Physics: Conference Series, 1280,* 1-5. https://doi.org/10.1088/1742-6596/1280/3/032019

Sugiono, S. (2017). *Metode penelitian kuantitatif kualitatif dan R&D.* Alfabeta.

Timothy, V., Watzka, B., & Stadler, M. (2023). Fostering preservice teachers' diagnostic competence in identifying students' misconceptions in physics. *International Journal of Science and Mathematics Education*, *21*, 1685–1702. https://doi.org/10.1007/s10763-022-10311-4

Usu, N., Rahmanpiu, R., & Marhadi, M. A. (2019). Analisis miskonsepsi siswa pada materi kesetimbangan kimia menggunakan tes diagnostik two tier multiple choice. *Jurnal Pendidikan Kimia FKIP Universitas Halu Oleo,* 4(3), 226-237. http://dx.doi.org/10.36709/jpkim.v4i3.11738.

Van Smeden, M., Lash, T. L., & Groenwold, R. H. H. (2020). Reflection on modern methods: Five myths about measurement error in epidemiological research. *International Journal of Epidemiology*, *49*(1), 338–347. https://doi.org/10.1093/ije/dyz251

Wahyuni, A. S. (2018). Konsepsi dan miskonsepsi siswa, mahasiswa calon guru, dan guru pada topik cahaya dalam pembelajaran fisika. *Jurnal Pendidikan Fisika, 6*(3), 235-250. https://doi.org/10.26618/jpf.v6i3.1503.

Wuryandani, W., & Herwin, H. (2021). The effect of the think–pair–share model on learning outcomes of Civics in elementary school students. *Cypriot Journal of Educational Sciences*, *16*(2), 627–640.

Yamtinah, S., Indriyanti, N. Y., Saputro, S., Mulyani, S., Ulfa, M., Mahardiani, L., Satriana, T., & Shidiq, A. (2019). The identification and analysis of students' misconception in chemical equilibrium using computerized two-tier multiple choice instrument. *Journal of Physics: Conference Series, 1157,* 1-7. http://dx.doi.org/10.1088/1742-6596/1157/4/042015

Yuliati, Y. (2017). Miskonsepsi siswa pada pembelajaran IPA serta remidiasinya. *Jurnal Bio Educatio, 2*(2), 50-58. http://dx.doi.org/10.31949/be.v2i2.1197

*** Prof. Dr. Suyono (Corresponding Author)**
Master Program of Science Education, Faculty of Mathematics And Natural Sciences,
State University of Surabaya,
Surabaya, East Java, Indonesia
Email: suyono@unesa.ac.id

Khurrotul Aini
Master Program of Science Education, Faculty of Mathematics And Natural Sciences,
State University of Surabaya,
Surabaya, East Java, Indonesia
Email: khurrotul.19019@mhs.unesa.ac.id

Dr. I Gusti Made Sanjaya
Master Program of Science Education, Faculty of Mathematics And Natural Sciences,
State University of Surabaya,
Surabaya, East Java, Indonesia
Email: igmasanjaya@unesa.ac.id