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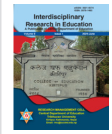

Exploring Chemistry Confusions and Misconceptions in Nepalese Secondary Education

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Keywords

Alternative conception, Chemistry, Experience, Misconception, Misunderstanding, Pre-conceived

Abstract

This study investigates the confusions and misconceptions in chemistry of ninth and tenth graders in Nepal. The primary objectives were to identify misconceptions in various areas of chemistry, determine their sources, and understand teachers' perceptions of these misconceptions. A concurrent mixed-method research design was employed, utilizing questionnaires and interviews for data collection. A random sample of 120 students from Grades 9 and 10 participated in the study. The findings revealed significant misconceptions in areas such as chemical reactions and stability, chemical equations, acids, bases and salts, and the periodic table. The main sources of these misconceptions were identified as common sense, textbooks, and teachers. The study highlights the importance of addressing these misconceptions to improve chemistry learning. It provides valuable insights for future research, aiding in the planning and development of theoretical and conceptual frameworks to better understand and mitigate misconceptions in chemistry education.

Introduction

Science is the descriptive knowledge of nature developed through the experience with nature, and it is the process of making rational perceptions toward all of those experiences and interconnecting the natural phenomenon (Cobern, 1996). Science is, in fact, the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment. Science is the systematic enterprise that builds and organizes the knowledge in the testable explanation and prediction of the universe. Science is not only the collection of facts, but also the process and body of knowledge. Science is a dynamically useful way of discovery and a global endeavor, i.e., anyone from anywhere can contribute to it (Rulev, 2021).

Chemistry is a branch of science which deals with the molecules and the transformation of molecules. Chemistry is the study of the properties of matter and their behavior which cover elements, compounds, atoms, molecules, radicals and ion, their properties and interaction (Tumay, 2016). Chemistry is not only related to the fewer elements but it involves the explanation of the interaction between atoms of those elements and how they makes things possible in our day to day activities. Misconceptions, which are also termed as alternative concepts are the ideas held by students regarding the scientific phenomenon. Throughout the ages, it is the major obstacle for understanding and conceptualizing science, science-related terminologies and phenomena. These are also termed as the blank spot, gap, or missing part of the full concept map (Eskilsson & Hellden, 2003). Misconceptions are false or non-scientific thoughts or knowledge of the students and scientific problems and are caused mainly by their misunderstanding. Misconception can be categorized into five type namely preconceived notion, non-scientific belief of conceptual misunderstanding, vernacular misconception and factual misconception. Preconceived thought of students are the pervasive thought of students which can be explained by using terms like misconception, alternative conceptions, preconceptions and alternative frameworks. All of these terminologies refer to the students' conceptions which are scientifically incorrect and based on their own analysis instead of scientific basis (Kay & Yin, 2010).

In the beginning, student has limited concepts related to anything which are based on their interaction with their surroundings, people and environment. But with guidance, their knowledge or concepts get some proximity and build up their knowledge (Subedi, 2021). The assumption of students 'molecules as the chemical species taking part in chemical reaction' is the limit of the student concepts which they have learned by their own exploration but with the interaction with their friends and teacher they can get proximity and learn that the actual particles taking part in a chemical reaction are the valence electrons of atoms of hydrogen and oxygen. In case of more intrinsic subject matters of chemistry have more misconceptions, like pH (Watson et al., 2020), Acid, base and salt (Dermicioglu,et. al, 2005), Reactivity and chemical stability (Christian & Yeezeiski,2012) and chemical reaction has a significant number of misconception as they cannot be visualize directly and due to the emerging nature of chemistry, sometimes they are hard to grasp. In this scenario, the interpretations that are done without any scientific basis can create havoc in learning process, if we could not detect the misconception earlier and create cognitive conflicts within them. Teachers must consider the learning approaches that help in finding misconceptions and help us to minimize the misconceptions among the students.

Misconceptions act as hurdle of learning which prevent meaningful learning of student (Taber, 2014). Misconceptions are conclusions made by students that cannot be accepted. But in case of student perception those are the perfectly fitted concept of their conceptual frame. The factors of such misleading gap are present experience, textbook, teachers, school teaching, school environment and culture. The complexity of chemistry has implication for the teaching of chemistry today. We know that chemistry is very complex subject from both research on problems solving and misconceptions are in abundant number not only because chemistry is complex but also because of the way concepts are being taught (Dias & Pedrosa, 2016).

Identification of the misconception is very much important because it helps to revise the curriculum and help our education system to minimize the conceptual errors which are contribute to the formation of misconceptions. Sometime the sources of misconception lie within the curriculum, text, way of explaining and representing the chemical and scientific phenomenon (Nakiboglu, 2003). When the misconception lies within the education system, it becomes a severe problem that cannot be eradicated easily. Exploration of the misconception allows textbook creators to make the representation, explanation and example relevant and less misleading. Along with the curriculum and textbook, this kind of exploration also helps us to plan the instruction strategies and evaluation strategies for the effective learning formation of concepts (Taber, 2014). Talking about the research on science education and specially chemistry education in context of Nepal, there are comparatively less number of researches has focused on the misconception in chemistry education. In context of Nepal, the lack of qualified, well-trained instructor, viable educational materials, well-equipped classes and science laboratories along with the insufficient practical based classes are affecting the quality of education of students (Pokharel, 2017).

School-level students of Nepalese school are naive learner of science and school level science curriculum aims to provide basic scientific knowledge to the students. School level chemistry especially chemistry include in book of grade nine and ten is the foundation of upper level chemistry. Thus misconceptions in these foundation level make hard for them to grasp vague array of chemistry which rely on these miniscule base. Misconception leads to misinterpretation and they failed to conceptualize chemical phenomena properly. At last they left it terming it as 'most difficult subject to understand' (Taber & Watts, 2000). Students' engagement in activities help to conceptualize science concepts (Acharya et al., 2022). So it is obvious to correct them from the very beginning and we should take misconception as an opportunity for better understanding of chemistry instead of take it as blockage.

Students frequently interact with their surroundings, friends, and teachers, and we cannot exclude the internet. All of these things provide them enough opportunities to gain information about whole lot of things. It's good as these things provide a lot of information to our beloved pupils, but is all of this information gained true or just some sort of cheesy fact without any scientific basis? What are our approaches to tackle all of these alternative conceptions and faulty interpretations? These types of questions are still unexplored and even some of us explored it, but nothing significant changes are visible to us. Research done in the field of science specifically chemistry mostly focuses on higher secondary level or university level misconception neglecting the fact that the major hurdle is created by very basic misconceptions. Pokhrel (2017) has conducted the research based on the misconception in science of school level but it has focused on entire science rather than chemistry only. There is serious gap for the exploration of misconceptions in chemistry from very basic and fundamental level. This research tend to fill that up. The children come to the class along with something and some background knowledge that may or may not have any scientific validation. Some of those concepts are fully based on their observation, common sense, or even previous school's misconception (Glasersfeld, 1995). The identification of areas and sources of misconception is the major objective of this research paper.

Methods and Materials

This research paper is based on the quantitative approach. Misconception is a very intricate topic and issue of chemistry education. If we tend to define it based on mere achievement test, we only get the right and wrong responses and fail to get the conceptual gap which are the main cause of wrong responses. While doing such type of achievement test, we won't be able to present the counterintuitive concept of the chemical phenomenon to the target group. The counterintuitive concepts have the possibilities to generate curiosity among scholars. If we go through the qualitative aspect only, our main objectives of analysis of misconception may get a complex structure. So, use only a quantitative research approach seems to be much more suited for exploring misconceptions. As the research process, the sampling method for the exploration of the misconceptions of students has followed random sampling whereas for the data collection procedure. For the purpose of data collection total 120 students were randomly selected. From grade 9, 60 students were selected and from grade 10 also 60 students were selected out of three secondary school of Kirtipur municipality of Kathmandu district of Nepal.

For the achievement of the designated objectives of the research, the researcher had designed the close-ended questionnaire having 50 questions related to the different area of chemistry i.e. State of matter, atom, molecule, element, compound and valency, periodic table, acid, base and salt, chemical reaction and chemical equation. All of the 50 questions had the 4 distracters. Along with that, at the end of each 50 question there were checkboxes for the collection of data related to sources of misconception. The checkboxes included (i) Textbook, (ii) Teacher, (iii) Commonsense, (iv)friends, (v) internet for the collection of data related to the sources of knowledge or misconceptions.

Results and Discussion

As the researcher had planned to use the questionnaire data and it was analyzed quantitatively. The data related to the sources of misconception which were obtained from the questionnaire was calculated quantitatively by calculating the frequency, percentage and mean. First of all, calculation for sources was done on each of the subject area on the basis of the frequency of selected option in each of the subject area and percentages of responses were calculated. After the percentages of each of the options in each of the subject area were listed, the calculation of the percentage mean was done and by comparing the mean percentage of each of the options provided in check box, the major sources of misconception were declared and explain quantitatively.

According to the purpose of this paper; misconceptions on student were explored by going through the collected data and analyzing them quantitatively and qualitatively. Table-1 presents the quantitative data calculated via MS Excel and presented as mean score and mean percentage.

Table 1

Analysis of Misconception on Different Area of Chemistry held by Student-quantitative Approach

S.N	Subject area	No. of question	Mean of score	Percentage
1	State of matter, physical and chemical change	8	4.16	52%
2	Elements, compounds, atoms, molecule, ions and valency	11	5.13	46.63%
3	Mixture and solubility	3	2	66.67%
4	Periodic table	7	4.83	69.00%
5	Chemical reaction and stability	6	2.2	32.50%
6	Metal and non-metal	5	3	60%
7	Acid, base and salt	6	2.3	38.33%
8	Chemical equation	4	1.3	36.67%
	Total	50		50%

Table 1 presents the quantitative analysis of misconceptions held by the students in school chemistry. Based on pre-set standard, subject area 'Chemical reaction and stability' has more number of misconceptions as it has the lowest mean percentage of 32.5%, 'chemical equation' at 36.67%, 'Acid, base and salt' at 38.33%, and 'Element, compound, atom, molecules, ion and valency' 46.63 %followed respectively and can be categorized in the group of subject areas of having comparatively more misconceptions. Meanwhile, the subject area having comparatively least misconceptions is the 'Periodic Table' with a mean percentage of 69%. Likewise, 'Mixture and solubility' 66.67%, 'metal and non-metal' 60%, and 'state of matter' 52% can be categorized under the group of subject areas having fewer misconceptions and fewer problematic. The average mean percentage of the score is 50% which seems satisfactory but not as much as desired.

The results of a quantitative analysis on student misconceptions in school chemistry, emphasizing certain areas where these misconceptions are more common. The topic "Chemical reaction and stability" is identified as having the most misconceptions, followed by areas like "Chemical equation" and "Acid, base, and salt." In contrast, the "Periodic Table" is noted for having the fewest misconceptions. Although the overall average score indicates a satisfactory level of understanding, there are still notable misconceptions across various chemistry topics that require attention.

Table 2.

Analysis of Source of Misconception in School Chemistry- overall Analysis

Subject area	Teacher	Textbook	Common sense	Friend	Internet
State of matter	33%	30%	27%	7%	3%
Atoms, molecule, element, compound, ion and valency	27%	23%	40%	10%	0%
Mixture and solubility	27%	33%	33%	0%	0%
Periodic Table	23%	43%	37%	0%	0%
Chemical reaction	27%	23%	50%	0%	0%
Metal and non-metal	30%	27%	43%	0%	0%
Acid, base and salt	33%	30%	27%	3%	7%
Mean %	30%	30%	36%	3%	1%

According to the analysis of the data presented in above table 2 the source of misconception in the 'State of matter" area of chemistry is a teacher with 33%. It means that the teacher is responsible for the conceptual gap. And then comes the textbook with 30%, common sense 27%, friends 7% and internet 3%. The sources of misconception in the area 'Atom, molecules, elements, compounds and ions', the highest percentage is for common sense with 40%. None of the students had chosen the internet option as their source of misconception. In area of mixture and solubility, highest percentage is for textbook and common sense with 33% in both of the options, teacher get the 27%, and friends. In case of the subject area 'periodic table' of school chemistry, 43% of total students selected textbook as the source of misconception which is followed by common sense 37% and the subject area- Metal and non-metal, total of 43% students selected the common sense as their source of knowledge. Teachers and textbook were considered as the source of knowledge by 30% and 27% of students. Similarly, subject area acid, base and salt, 33% of students had taken teacher as their major sources of knowledge. Textbook-30%, common sense- 27%, friends-3% and internet-7% are considered as the sources of their knowledge.

By the analysis for overall sources of knowledge, 36% students selected their common sense as the sources of their knowledge; teacher and textbook got the equal percentage of the response from i.e. 30-30%. Friend and internet got response from 3% and 1% of students as their source of knowledge. From the analysis of their responses it is found that students have significant misconceptions on chemistry which is 50% in average. Those misconceptions seem to be occurred by common sense, textbooks, teachers and very likely internet. From the quantitative analysis, it can be said that the higher amount of misconceptions results by the commonsense of the students which are probably the result of their own experience and interaction with surrounding and people around them. In my perception, the major source of misconception among students are internet and their experience in day-to-day life. In the current scenario of the pandemic and online education, the internet is also rising as the major source of misconception.

It is found that significant number of students have misconception in various area of chemistry. It is found that students have misconception in the area of reaction and stability, acids, base and salts. From the analysis of sources of misconception, it is found that most of the students have selected their common sense as the source of knowledge. In case of the analysis of the interview with the teacher, it can be concluded that students generally have misconceptions on abstract area of the chemistry that cannot be visualized. The sources of misconception in the eyes of the teacher are students' interaction with outer world and their misinterpretation of the given information. Conceptual change theory said that the construction of the knowledge takes place by active generation of concepts when there are conflicts between prior concept and new information (Posner,et. al, 1982). If students failed to bring change in prior concepts specially the alternative concepts, they cannot grasp the new correct concepts. We can only bring positive change among students when we provide enough opportunities for such conflicts and help to remove the older and irrelevant concepts (Cobern, 1996). In case of misconception in the fundamental area of chemistry i.e. state of matter, chemical and physical change, students have prior concepts based on their surface observation until and unless they are introduced to the true concepts, they won't understand or they won't form conceptual framework of this chemical phenomenon.

Heman-Abell and DeBoer (2011) on their research has also talked about the hierarchies of misconception in chemistry. They have used the distractor-driven standard-based multiple assessments to explore misconceptions in chemistry. Strong distractor can point out the conceptual gap and can contribute to find the misconception among students. Watson, Dubrovskiy and Peter (2020) has conducted the research to test the student's knowledge, confidence and conceptual understanding of pH. Students has a significant amount of misconception. In case of misconception related to the reaction of hydrogen and oxygen, they mentioned that the molecules of hydrogen and oxygen take part in chemical reaction because they have seen H_2 and O_2 written in chemical equations. They explored and thought the particles that take part in chemical reactions are molecules.

Effective and practical based science teaching and learning is the burning issues of all time. Most of the paper available on web, curriculum designer, and policy makers are focusing on the 'effective science education', but in case of Nepalese context, there is minimal change. When we are talking about scientific literacy, scientific attitudes and effecting science teaching and learning, we must not avoid the misconceptions. I had found that some of us still believe the information provided in textbooks is highly reliable. Yeah, I accept that books are reviewed several times; publishers edit is several times to make it errorless. But we also have to accept that the text and paraphrase given in the textbook may be understandable to us but that might be misleading to the students. If textbook mentions about octet and duplet state, talks about the valency they must talk about not all the elements obey the octet and duplet rule so that their concept does not necessarily stick on octet and duplet when we explain the bond in ammonium. When we talk about the Bohr model of atomic structure, we must provide the representation of atoms throughout time so that they can understand that science is not steady, it is dynamic and new ideas and concepts always replace the old ones.

While talking about the source of misconception, only valid and reliable sources should be introduced to the students. Students are frequently evolving, observing and collecting information. They have their kind of explanation of anything which we can consider as their 'common sense'. Their self-made reality may be far away from actual reality. Formation of new plans of instruction, assessment, and evaluation may not always result in proper conception and improvement of achievement (Acharya, 2016; Ozmen, 2007). This might happen due to the abstract nature of the chemisty and the emergence in chemistry (Tumay, 2016). A higher number of misconceptions is observed in the subject areas like chemical stability & reaction, chemical equation and acid, base & salt with an average score of 32.50%, 36.67%, and 38.33%. This result shows the difficulty students have with these abstract topics of chemistry. This research can be used to minimize the possible misrepresentation and misinterpretation of information from a variety of sources like books. It also helps to plan instruction so that one can be aware of the authentication of information from possible sources.

Effective and practical-based science teaching and learning remain critical issues globally, with particular challenges in the Nepalese context. Despite the abundance of literature and the focus of curriculum designers and policymakers on effective science education, minimal progress has been observed in Nepal. Research highlights that misconceptions play a significant role in impeding scientific literacy and attitudes (Majeed et a., 2023; Barke & Buchter, 2023). One persistent issue is the unquestioned reliability of textbooks, often perceived as the ultimate authority on scientific knowledge. While textbooks undergo rigorous reviews (Rahmawan & Ashfarini, 2023; Shiddiqi et al., 2024), studies reveal that the content can still lead to misconceptions, especially when simplifications, like the octet and duplet rules, are presented without exceptions (Jammeh et al., 2023). Scholars argue that science is dynamic, and historical shifts in atomic models (Suparman et al., 2024; Riddle & Lo-Fan-Hin, 2023) should be emphasized in classrooms to foster critical thinking and adaptability. Effective science teaching must therefore integrate evolving scientific perspectives, ensuring that students move beyond static textbook knowledge and engage with the fluid nature of scientific discovery (Machová & Ehler, 2023).

Conclusions

This paper concluded, in school level chemistry students have a lot of misconceptions in fundamental areas of chemistry topics. Concepts of physical and chemical change, state of matter, atoms, elements, molecules, compounds, ions and valency, mixture and solubility, periodic law and trends, chemical equation, reaction and stability, metal and non-metal, acid, base, and salts are fundamental concepts of chemistry which play a vital role in case of understanding the chemical phenomenon in higher level. The misinterpretation and misconceptions in these fundamental ideas can lead to the never-ending loop of misconception which will be very tough to break. In the brighter side, if students become aware of the misconception and cure that misconception on time then they can understand the chemical phenomenon in the broader picture.

This study explores the prevalence of misconceptions among secondary-level students in Nepal regarding fundamental chemistry concepts. Misunderstandings in areas such as physical and chemical changes, atomic structure, valency, and periodic trends present significant barriers to deeper learning and hinder students' ability to grasp more complex chemical phenomena in higher education. The findings reveal that textbooks, teachers, and common-sense reasoning are primary sources of these misconceptions, creating a persistent cycle that can be difficult to break. However, the research also suggests a positive outlook: by identifying and addressing these misconceptions early, students can develop a more accurate and comprehensive understanding of chemistry. This study emphasizes the need for targeted interventions, teacher training, and curriculum reforms to mitigate these challenges, ensuring that students can achieve scientific literacy and competence in chemistry. It is recommended that curriculum developers and educators revise textbooks and teaching materials to include more accurate explanations of fundamental chemistry concepts, addressing common misconceptions directly. Additionally, regular professional development for teachers should focus on equipping them with the skills to identify and correct misconceptions in the classroom, promoting a deeper understanding of chemistry among students.

References

Acharya, K. P. (2016). Fostering critical thinking practices at primary science classrooms in Nepal. *Research in Pedagogy*, *6*(2), 1-7. https://doi.org/10.17810/2015.30

Acharya, K. P., Budhathoki, C. B., & Acharya, M. (2022). Science Learning from the School Garden through Participatory Action Research in Nepal. *Qualitative Report*, *27*(6).

Barke, H. D., & Büchter, J. (2023). Laboratory jargon and misconceptions in Chemistry–an empirical study. *ASEAN Journal of Science and Engineering Education*, *3*(1), 65-70.

Christian, B.N., & Yezierski, E.J. (2012). Development and validation of an instrument to measure students' knowledge gains for chemical and physical change for grade 6-8. *Chemistry education research and practice.3,* 384-393. http://doi.org/10.1039/C2RP200041D

Cobern, W. W. (1996).Worldview theory and conceptual change in science education. *science education.80*(5),579-610.

Creswell, J.W. (2015). *Research design: qualitative, quantitative, and mixed methods approaches*. Singapore: Sage

Dermircioglu,G.,Ayas,A., & Dermircioglu.H. (2005).Conceptual change achieved through a new teaching program on acid and bases. *Chemistry Eduction Research and Practice.1*, 36-51.

Dias,M.H., & Pedrosa, A.M.(2000). Chemistry textbook approaches to chemical equilibrium and student's alternative conception. *Chemistry education research and practice*, *2*,227-236.

Eskilsson,O., & Hellden, G. (2003). Longitudinal study on 10-12 years olds' conceptions o f the transformation of the matter. *Chemistry education research and practice.4*, 291-304. https://pubs.rsc.org/en/content/pdf/article/2003/rp/B2RP90046G

Eybe,H., & Schmidt,H.J. (2004).Group discussion as a tool for investigating students' concepts. *Chemistry education research and practice. 5*(3), 265-280.

Herman-Abell,C.F., & DeBoer,G.E (2011).Using distractor-driven standards-based multiple choice assessments and rasch modeling to investigate hierarchies of chemistry misconception and detect structural problem with individual items. *Chemistry education research and practice*. *2*(12), 184-192. https://doi.org/10.1039/C4RP90728F

Jammeh, A. L., Karegeya, C., & Ladage, S. (2023). Misconceptions on Basic Stoichiometry among the Selected Eleventh-Grade Students in the Urban Regions of the Gambia. *Journal of Baltic Science Education*, *22*(2), 254-268.

Johnstone, A.H. (2000).Teaching Chemistry- Logical or Psychological. *Chemical education and research practice.1*.9-15. https://doi.org/10.1039/A9RP90001B

Kay C.C., & Yiin,H.K. (2010). *Misconception in the Teaching of Chemistry in Secondary Schools in Singapore and Malaysia.* Sunway college Johar Bahru,Malaysia.

Machová, M., & Ehler, E. (2023). Secondary school students' misconceptions in genetics: origins and solutions. *Journal of Biological Education*, *57*(3), 633-646.

Majeed, S., Ahmad, R., & Mazhar, S. (2023). An Exploration of Students' Common Misconceptions in the Subject of Chemistry at Secondary Level. *Annals of Human and Social Sciences*, *4*(2), 265-272.

Nakiboglu, C. (2003). Instructional Misconceptions of Turkish Perspective Chemistry Teachers About Atomic Orbital and Hybridization. *Chemistry education research and practice.4*,178-188. https://doi.org/10.1039/B2RP90043B

Ozmen, H. (2007). The Effectiveness of Conceptual Change Text in Remediating High School Students' Alternative Conceptions Concerning Chemical Equillibrium. *Asia Pacific Education Review. 8*(3), 413-425. http://doi.org/10.1007/BF03026470

Pokharel, J. (2017). *Students' Misconception in Science at Secondary Level: A Quest of Exploration.* An unpublished M.Ed thesis, Department of science and Environment education. TU. Kirtipur

Posner, G. J., Strike, K. A., Hewson, P.W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education. 66*(2), 211-227.http://doi.org/10.1002/sce: 3730660207

Rahmawan, S., & Ashfarini, D. (2024). Identification of Misconceptions and Causes of Misconceptions in Stoichiometry Material Using Four Tier Multiple Choice (4TMC). *Orbital: Jurnal Pendidikan Kimia*, *8*(1), 39-48.

Riddle, H., & Lo-Fan-Hin, S. (2023). Students' Misconceptions in Chemical Equilibria and Suggestions for Improved Instruction. *New Directions in the Teaching of Natural Sciences*, *18*(1), n1.

Rulev,A. (2021). Chemical Education contra Chemophobia.*CHIMIA International journal for chemistry. 75*(1), 98-100.http://doi.org/10.2533/chimia.2021.98

Sevendsen (2021), The Nature of Science and Technology in Teacher Education: Intechopen

Shiddiqi, M. H. A., Arthamena, V. D., Ayyubi, M., Manarisip, A. J., &

Aznam, N. (2024). Systematic Literature Review: Analysis of Misconception Problems and Diagnostic Instruments for Learning Chemistry. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 168-179.

Subedi, R. R. (2021). Constructivist Approach in Learning Chemistry: A Case of High School in Nepal. *Interdisciplinary Research Education*. *6*(2), 35-42. https://doi.org/10.3126/ire.v6i2.43535

Suparman, A. R., Rohaeti, E., & Wening, S. (2024). Student Misconception In Chemistry: A Systematic Literature Review. *Pegem Journal of Education and Instruction*, *14*(2), 238-252.

Taber, K.S. (2014). The Impact of Chemistry Education Research on practice: A cautionary tale. *Chemistry Education and research.15*,410-416.https://doi.org/10.1039/C4RP90009J

Taber, K.S., & Watts, M. (2000). Learners's Explanation for chemical phenomena. *Chemistry Education Reasearch and practice*.*3*.329-353. https://doi.org/10.1039/B0RP90015J

Tumay, H. (2016). Reconsidering learning difficulties and Misconception in Chemistry: Emergence in Chemistry and its implication for Chemical Education. *Chemistry Education and Research.17*, 229-245.https://doi.org/10.1039/C6RP00008H

Von Glasersfeld, E. (1995). *A constructivist approach to teaching*. Lawrencen: Erlbuam, Hillsdale NJ.*3*-15. http://www.vonglasersfeld.com/172

Watson, S.W., Dubrovskiy, A.V., & Peter (2020).Increasing Chemistry Students' Knowledge, confidence and conceptual understanding of pH using a collaborative computer pH simulation. *Chemistry education research and practice. 2*.528-535.