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Conceptual Change Strategies to Remediation Chemistry Students' Misconceptions: A Literature Review

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ABSTRACT

Misconceptions are a common problem in chemistry learning, both among students and college students, which can hinder the process of conceptual understanding. This study aims to assess the effectiveness of the Conceptual Change strategy in reducing misconceptions among chemistry students. The research method used was a literature review by examining five national articles published in the last five years with the subject of chemistry education students. The results of the study indicate that the Conceptual Change strategy is effective in reducing misconceptions through various models and approaches. The Conceptual Change model combined with the Three Scientific Questions (CCM-EWTQ) has been proven to be able to help students identify and correct misconceptions on the concept of acid-base indicators. The integration of the Conceptual Change strategy with the recall process also produces positive impacts in the form of increased cognitive conflict, strengthening long-term memory, and reducing the burden of misconceptions. In addition, the development of LKPD and software based on Conceptual Change shows a high level of validity, practicality, and effectiveness in helping shift conceptions from misconceptions to conceptual understanding. A key finding of this study is that Conceptual Change not only functions as a remediation strategy but also plays a role in restructuring conceptual knowledge, strengthening memory, and developing students' critical and scientific thinking skills. Therefore, the Conceptual Change strategy is relevant for improving the quality of chemistry learning in higher education.

INTRODUCTION

Education is a process of self-development and personality development, encompassing knowledge, skills, attitudes, and values. Education is essential for every student to develop their potential, knowledge, and abilities (Mahmuda & Sunarso, 2025). Education is an effort to develop student abilities through guidance, learning, and training. Education is not only a process of transferring information but also an understanding of the concepts taught, as concepts are the foundation of thinking (Mu'arikha & Qomariyah, 2021).

A concept is a foundation for thinking that can solve problems in a learning process. A concept that is incorrectly interpreted can result in misunderstandings and, if persisted, can lead to misconceptions (Nurrahmah & Sukarmin, 2023). Misconceptions are misunderstandings that occur in students regarding concepts in knowledge construction that do not align with the conceptual rules of experts (Nasir, 2020). Student misconceptions can affect understanding during the learning process, because when students experience misconceptions, they are highly likely to experience misconceptions again in subsequent learning (Wati & Novita, 2021).

Based on Lemma's (2013) research, 90% of misconceptions among students are caused by misconceptions among teachers. Misconceptions about basic chemistry

concepts also occur among prospective chemistry teachers (Palisoa et al., 2021). Misconceptions among students, prospective teachers, and teachers can be immediately corrected by designing remedial learning. Recommended misconception management for chemistry students can be done by using conceptual change strategies (Pabuccu & Geban, 2006) in Permatasari et al. (2024).

Conceptual Change strategies play a crucial role in addressing misconceptions embedded in students' cognitive structures (Sumarni & Siadi, 2012). Conceptual Change is one way to help students overcome misconceptions by restructuring their conceptual knowledge (Rodrigues & Thacker, 2019). Students must be dissatisfied with their existing concepts for conceptual change to occur. Consequently, new concepts must feel more understandable, rational, and useful. This study will examine how conceptual change strategies reduce misconceptions among chemistry students.

RESEARCH METHOD

This research was conducted using a literature review method. The literature review method, also known as library research, is a data and information collection technique that examines written sources to thoroughly examine, assess, and consolidate relevant published works. National articles published online were included as the research population. The article selection process also applied the criterion that the research subjects used were chemistry education students. The research data was based on the data criteria required in this review, selecting 5 (five) appropriate articles published within the last 5 years. The results of previous research were taken from 5 articles, these articles were selected because they researched conceptual change strategies in remediating misconceptions in chemistry learning which only focused on chemistry education students so that 5 articles were obtained that were most relevant to this research. The data collected from the 5 (five) articles were then analyzed by briefly explaining the research findings. Conclusions were drawn by examining the consistency and interrelationships between the findings of the studies reviewed.

RESULTS AND DISCUSSION

The following Table 1 explains the publication of indexed journals and Table 2 explains the results of the analysis carried out through literature studies, namely:

Table 1. Indexed Journal Publication in Indonesia

Year	Article Title	Journal Name	Type of Publications
2024	Investigating Students' Conception of Acid-Base Indicators Using Three Scientific Questions-Enhanced Conceptual Change Model	Jurnal Pendidikan MIPA	Sinta 2
2022	The Effectiveness of Remediation Learning Strategy in Reducing Misconceptions on Chemistry: A Systematic Review	TADRIS: Jurnal Keguruan Dan Ilmu Tarbiyah	Sinta 2

Year	Article Title	Journal Name	Type of Publications
2022	Feasibility of Students Worksheets Using Conceptual Change to Remedy Misconceptions on Chemical Bonding Material	Journal of Chemistry Education Research	Sinta 3
2022	Software Development to Reduce Misconceptions Using Conceptual Change Text Strategy on Chemical Bonding Matter	International Journal of Chemistry Education Research	Sinta 4
2021	Strategi Conceptual Change Terintegrasi Recall Memfasilitasi Proses Terjadinya Konflik Kognitif dan Reduksi Beban Miskonsepsi Mahasiswa Calon Guru Kimia	Molluca Journal of Chemistry Education (MJoCE)	Sinta 4

Table 2. The Result of Literature Analysis of Articles on the Conceptual Change Strategies in Reducing Misconception

Researcher	Research Method	Research Findings
(Permatasari et al., 2024)	Mixed method design, combines qualitative and quantitative methods	Based on research conducted, the application of the Conceptual Change Model with Three Scientific Questions (CCM-EWTSQ) has been proven to reduce misconceptions among prospective chemistry teachers regarding the concept of acid-base indicators. This confirms that the CCM-EWTSQ can help correct misconceptions and improve students' conceptual understanding.
(Islamiyah et al., 2022)	Systematic Literature Review (SLR)	Based on this research, it can be concluded that students construct their understanding through the processes of assimilation and accommodation. An imbalance between these two aspects will lead to misconceptions. Six learning strategies are highly effective in reducing misconceptions in chemistry: POE, guided inquiry, MRCD, Ember, Conceptual Learning, and ECIRR.
(Rizqiyyah & Novita, 2022)	Research and Development (R&D)	Based on the research that has been conducted, it can be seen that the development of LKPD with a conceptual change model to overcome students' misconceptions on chemical bonding material is declared feasible, in terms of validity of 81%, practicality of 94.01%, and effectiveness of 63%.

(Putri & Sukarmin, 2022)	Research and Development (R&D)	Based on the research conducted, it can be concluded that the developed software is suitable for detecting and reducing misconceptions, with an average percentage shift from misconception to understanding the concept of 85.53%.
(Palisoa et al., 2021)	Remediation Approach	Based on the research results obtained, it can be seen that the integrated conceptual change recall strategy has a good impact on (1) the recall process helps provide misconception information stored in long-term memory, (2) there is an increase in cognitive conflict, causing easy changes in conceptions, (3) there is a decrease in the burden of misconceptions (MK) to know the concept (TK).

Based on Table 2, an analysis of five research articles reviewed on the application of conceptual change strategies to reduce misconceptions in chemistry students. The studies conducted included Research and Development (R&D), SLR, remediation approaches, and mixed methods. The conceptual change strategies implemented by these researchers utilized several models, including the Three Scientific Questions, the recall process, and the development of conceptual change-based media.

Research conducted by Permatasari et al. (2024) showed that the application of the conceptual change model with the three scientific question approach (CCM-EWTQ) effectively reduced misconceptions of prospective chemistry teachers, especially on the concept of acid-base indicators. The stages carried out included (1) Before entering the remediation program using CCM-EWTSQ (screening stage), students worked on questions regarding the concept of acid-base indicators, 10 items were understood by TK, 1 item by TTK, and 5 items by MA. This student's MK degree is 31.25%; (2) Verification of misconceptions, researchers conducted two verification processes using diagnostic tests and analysis of students' written answers. Students were asked to write down their understanding of the concept of acid-base indicators, then compared with the correct scientific concept according to chemists. This ensures that only students with misconceptions are truly involved in the remediation program; (3) Creation of cognitive conflict, this stage was carried out twice (two cycles of cognitive conflict). Students were confronted with experimental results, virtual simulations, or conceptual illustrations that contradicted their initial understanding. The first cognitive conflict raises awareness of conceptual errors, while the second cognitive conflict strengthens the urge to abandon old concepts and scientific concepts. This stage is a novelty from the research conducted by Permatasari et al. (2024) which lies in the design of creating double cognitive conflicts that are carried out sequentially and gradually, to ensure that students truly experience conceptual dissonance before accepting scientific concepts. This model differs from the classic CCM which only creates one cognitive conflict. By creating two cognitive conflicts, it can guarantee deeper mental involvement from students, avoid half-finished conceptual changes, and encourage a more stable and long-lasting restructuring of conceptual knowledge; (4) Providing assistance for the balance process. Aims to help students achieve a balance between old and new concepts. The steps taken are given in

two stages, the first stage is standard equilibration, students are guided to understand new concepts correctly through discussions, worksheets, and directed explanations; the second stage is equilibration with enrichment carried out to strengthen understanding and link new concepts to the context of epistemology and axiology. Students can show significant improvement in conceptual understanding, although some have not fully understood the epistemological and axiological dimensions of the acid-base concept; (5) Reconstruction of final understanding to assess the extent to which students have succeeded in rebuilding their conceptual understanding stages after going through the previous stages. Students are given a post-test to measure conceptual reconstruction. The level of student conceptual reconstruction reached an average of 57%, indicating partial success. Some other students still experience difficulties in the epistemological and axiological dimensions.

Furthermore, research by Islamiyah et al. (2022) using the Systematic Literature Review (SLR) method balances the assimilation and accommodation processes, helping students reconstruct their understanding based on correct scientific concepts. This strategy is carried out through four main stages: (1) Exploration and Identification of initial concepts, to reveal students' initial conceptions to determine which are correct and which are misconceptions. Researchers provide diagnostic tests, interviews, and discussions to determine students' initial understanding. Students are asked to explain chemical phenomena using their own understanding, for example about reactions, the structure of substances, or the properties of solutions. This stage results in a classification of conceptions into three: understanding the concept, not understanding, and misconception; (2) Concept confrontation, creating cognitive conflict so that students realize that their initial conceptions are not in accordance with scientific concepts. Students predict the results of certain experiments then find that the results do not match their initial predictions. Cognitive conflict encourages students to question their old beliefs and begin to open themselves to correct scientific concepts; (3) Concept accommodation reconstruction, helping students build new understandings that are in accordance with scientific concepts after cognitive conflict arises. Students use visual media, videos, simulations, or conceptual change-based teaching materials that strengthen scientific concepts. Students begin to accept new concepts and connect them with revised prior knowledge. This stage is a novelty in research conducted by Islamiyah et al. (2022) namely by integrating digital learning media based on conceptual remediation used as a means of conceptual accommodation, not just verbal explanations from teachers, the accommodation process not only focuses on changes in individual conceptions, but is also linked to interactive approaches based on technology and inquiry, thus enabling students to experience conceptual restructuring themselves through visualization and independent exploration, not just passively receiving new information; (4) Application and evaluation of new understanding, to ensure students truly understand and can apply new concepts in different contexts, is carried out through concept application, reflective discussions, and post-remediation understanding evaluation. The results show that students experienced a significant decrease in misconceptions and an increase in conceptual understanding scores.

Rizqiyyah and Novita's (2022) research also strengthens previous findings by developing a conceptual change model-based LKPD which was declared feasible and effective with a validity value of 81%, practicality of 94.01%, and effectiveness of 63%. The stages carried out in this study were; (1) Exposing alternative frameworks, to identify students' initial understanding of a concept, including their misconceptions. Students answer questions or chemical phenomena to be analyzed based on their initial knowledge before being given the correct scientific concept. This stage is a novelty carried out by Rizqiyah and Novita (2022) namely by designing directly in the form of LKPD not only verbal discussion activities as in previous studies, combined with a three-tier diagnostic test to detect and map the level of student misconceptions before and after the use of LKPD, the mechanism for analyzing student conceptions becomes more structured because each tier of the test measures conceptual answers, student reasons, and the level of confidence in their answers; (2) Creating conceptual conflict, to make students realize that their initial conception is not in accordance with the correct scientific concept, participants discuss or compare the results of initial predictions with scientific explanations so that they feel "dissatisfied" with the old conception; (3) Encouraging cognitive accommodation, guiding students in forming new, more scientific concepts through the cognitive restructuring process, students make conclusions or new concept maps in accordance with the correct scientific explanation.

Similarly, Putri and Sukarmin's (2022) research shows the effectiveness of conceptual change-based learning in reducing the level of student misconceptions. The percentage of shifts from the category of misconceptions to knowing the concept reached 85.53%, which indicates high success in changing erroneous conceptions into scientific concepts. The stages carried out in this study are; (1) Showing students' initial conceptions, to identify students' initial understanding of a concept, carried out through a pretest using the four-tier diagnostic test method to determine the level of students' initial misconceptions; (2) Creating conceptual conflicts, aimed at raising doubts about wrong concepts, students are faced with phenomena, animations, or texts that contradict their initial understanding so that a condition of "disequilibrium" arises, through software, this conflict is raised interactively, so that students realize that their old concepts cannot explain the phenomenon correctly. This stage carries out the novelty carried out by Putri and Sukarmin (2022), namely by using interactive CCT-based software to create conceptual conflicts, which is a new approach that makes students more active and reflective about their misconceptions. Students interact directly with the system, not just passively reading text, so that conceptual conflicts occur independently and in a directed manner; (3) Balancing process, to rebalance the conceptual structure of students, students compare old concepts and new concepts with the help of conceptual change text that is arranged systematically; (4) Concept reconstruction, to re-form correct conceptual understanding. Strengthened through a post-test on the software using the same method (four-tier test) to see the shift from misconceptions to “knowing the concept”.

In addition, research by Paliosa et al. (2021) using a conceptual change-based remediation approach integrated with the recall process showed positive results. The stages carried out in this study were; (1) The misconception confirmation stage, to

identify and confirm misconceptions held by students, so that they can become the basis for further intervention. Students were asked to recall concepts that had been stored in long-term memory. Then students answered questions and indicated the level of confidence in the concepts believed to be correct. This stage is a novelty in research conducted by Paliosa et al. (2021), namely integrating the recall stage first to explore misconceptions stored in long-term memory before creating cognitive conflict, combining information processing theory with the conceptual change model, and making the process of conceptual change more effective because it starts from data on misconceptions that students actually have; (2) The cognitive conflict creation stage, to encourage students to feel dissatisfaction with old concepts so that they are ready to accept new concepts. Students feel confusion, shock, and discomfort because their old concepts conflict with the scientific evidence provided; (3) The stage of reducing the burden of misconceptions and changing conceptions, an accommodation process occurs according to Piaget's theory, where students adjust old concepts to suit new, correct information, students revise and rebuild their understanding based on correct scientific concepts through discussion, reflection and confirmation with lecturers, students improve their cognitive structure, the result is a reduction in the burden of misconceptions (MK) to knowing the concept (TK).

All studies demonstrated effectiveness in reducing misconceptions and improving conceptual understanding in chemistry students. The conceptual change strategy proved effective because it emphasized the process of restructuring knowledge through cognitive conflict, guided scientific questions, and inquiry-based learning and remediation. Overall, the analysis of the five studies showed that the conceptual change strategy is a highly effective approach in reducing chemistry students' misconceptions. Its effectiveness lies in its ability to facilitate scientific thinking processes through the creation of cognitive conflict, comparisons between initial concepts and scientific concepts, and restructuring understanding based on empirical evidence. Thus, the application of the conceptual change strategy not only functions as a remediation for misconceptions, but also as a means of developing critical thinking skills and in-depth conceptual understanding in chemistry learning.

CONCLUSION

Based on the results of a literature review of the five research articles reviewed, it can be concluded that the conceptual change strategy has proven effective in reducing misconceptions among prospective chemistry teacher students through restructuring conceptual knowledge and creating cognitive conflict. The application of various models, such as the Three Scientific Questions, the recall process, and the development of conceptual change-based media, showed valid, practical, and effective results in reducing the percentage of misconceptions. Thus, this strategy not only functions as remediation but also improves students' conceptual understanding and critical thinking skills in chemistry learning.

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