THE DEVELOPMENT OF A TWO-TIER DIAGNOSTIC TEST TO DETECT STUDENT'S MISCONCEPTIONS IN LEARNING PROCESS

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Abstrak: *Tujuan dari penelitian ini adalah untuk membuat instrumen diagnostik pilihan ganda dua tingkat untuk mengidentifikasi miskonsepsi siswa. Dalam pengembangan instrumen ini, 207 siswa dilibatkan dalam wawancara, tes esai, tes pilihan ganda dengan alasan terbuka, dan tes diagnostik dua tingkat. Persamaan alpha Cronbach menghasilkan nilai dependability sebesar 0,764 untuk 16 pertanyaan valid. Berdasarkan analisis miskonsepsi terhadap enam konsep utama, mayoritas siswa mengalami miskonsepsi. Secara keseluruhan, instrumen tersebut cukup efektif untuk menentukan miskonsepsi siswa. Untuk menilai miskonsepsi siswa tentang asam dan basa, instrumen ini dapat digunakan sebagai pengganti tes.*
Kata kunci: miskonsepsi, tes diagnostik, pilihan ganda two-tier

Abstract: *The goal of this study was to create a two-tier multiple-choice diagnostic instrument to identify students' misconceptions. In developing this instrument, 207 students were involved in interviews, essay tests, multiple-choice tests with open reasons, and two-tier diagnostic tests. The Cronbach's alpha equation yields a dependability value of 0.764 for the 16 valid questions. Based on the misconception analysis of the six main concepts, the majority of students had misconceptions. Overall, the instrument is quite effective for determining student misconceptions. In order to assess students' misconceptions about acids and bases, this instrument might be used as a substitute test.*
Keywords: misconceptions, diagnostic test, two-tier multiple choice

Introduction

The educational process has a close relationship with the achievement of educational goals. The learning process, which comprises teaching and learning activities, is the main component of the educational process. However, in accordance with the nature of teaching as a process namely, the process of arranging the environment around students in order to foster and encourage students to carry out the learning process — learning and teaching activities must also go through a number of carefully planned activities (A. Cetin, 2011). To successfully achieve the educational objectives, the learning process must unquestionably meet the teaching objectives. The expected performance of students after studying a certain subject is described in the teaching objectives (P. Faturrohman, 2007). One of the learning goals, particularly in high school chemistry, is for students to comprehend chemical ideas, principles, laws, and theories as well as how they relate to one another and how they may be used to solve issues in both the real world and the environment (S.A. Pranajaya, 2020). Based on the objectives of high school chemistry learning, mastery of concepts correctly and precisely is very important because it will give birth to a correct understanding of laws, principles, and theories. However, often students cannot understand the concepts conveyed by the teacher in the learning process. Thus, influencing learning outcomes and students' thinking patterns on other topics that are still related.

One of the causes of students' inability to understand concepts is when they experience misconceptions (Hamalik, 2011). Misconceptions are differences between students' views and views based on accepted knowledge. Misconceptions and learning the natural sciences have a very close relationship. One of

the main principles of inquiry is that students can construct their own understanding by carrying out active activities in their learning. It can be concluded that one of the reasons the science learning process has a strong potential for misconceptions is because the inquiry approach emphasizes the student center, as previously explained regarding the impact of the student center, which has the potential to lead to misconceptions by students (Karadeniz, 2013). Based on this misconception theory, the teacher has the task of diagnosing any misconceptions experienced by students so that they can help them prevent or change these misconceptions into proper concepts (Z. Muchtar, 2012). Identifying these misconceptions is important because it is an instructional strategy that ultimately proven effective in combating misconceptions that are differentiated based on the types and sources of misconceptions. The identification that has been carried out in identifying student understanding and misconceptions is the acid-base concept by previous researcher.

In order to fully grasp the issue of acids and bases, it is necessary to have a thorough comprehension of a number of fundamental introductory chemistry ideas, including equilibrium, collision theory, the theory of molecular kinetics, and the particle characteristics of substances. Apart from that, this topic is the basis for further learning in the high school chemistry learning process, such as the topic of hydrolysis and buffer solutions (Zulfiani, 2009). Therefore, if students experience misconceptions that are not immediately detected, they will have an impact on subsequent topics, which will result in not achieving the teaching objectives. The acid-base topics studied in class XI consist of basic chemical concepts that study the development of acid-base theory, acid-based solution indicators, pH concepts, acid-base equilibrium constants (Ka/Kb), pH calculations, and the application of the pH concept to the environment. These concepts must be mastered correctly and precisely by students, because if they experience misconceptions, they will experience obstacles in learning the next chemical concepts, which are closely related to the concept of acids and bases.

Efforts to achieve teaching goals in the learning process so that educational goals can be fulfilled properly can be done by always evaluating the teaching carried out by the teacher (E. Nurfalah, 2020). The teaching system itself is the implementation of the curriculum with the goal of fostering learning in the classroom (W.S. Zainuddin, 2022). Teaching evaluation is a component of the teaching system (N. Afandi, 2022). From this, it can be inferred the significance of the assessment process as a check on the execution of an effective learning process in line with the curriculum in order to achieve educational objectives. It is important for teachers to carry out activities to overcome misconceptions during the evaluation stage. Some of the methods used by the teacher in evaluating students to find out student misconceptions include conducting interviews, having students make concept maps, taking essay tests, and taking diagnostic tests. When connected with chemistry concepts, a diagnostic test is one of the right ways to be used in this evaluation stage (Ozmen, 2004).

Efforts to detect misconceptions are often carried out by using test instruments (multiple choice tests and descriptions) and non-tests (interviews, observations, and questionnaires) (Sheppard, 2006). Multiple choice tests are often used in science subject tests compared to interviews, but multiple-choice tests cannot guarantee students will answer seriously or just guess. In contrast to interviews, which can show thoroughly the level of understanding of students, the drawback is that it takes a relatively long time to interview many students (L. Yuniwarti, 2020). A two-tier diagnostic test instrument is another tool that can be used to identify misconceptions. This kind of test was created by an earlier researcher in his study that covered the creation and use of the diagnostic test to assess students' scientific misconceptions.

Methode

This research is aimed at uncovering students' misconceptions on the topic of acid-base solutions in class through a diagnostic test using a two-tier test. Based on the research objectives, researchers used a qualitative descriptive research method. The main research subjects were informants from high school classes XII and XI. The instruments used in this study were interview guides with students, written tests in the form of essay tests, multiple choice tests with open reasons and two-tier diagnostic tests. The processing of the interview results includes the stages of transcribing the results of the interview tests and analyzing the results of the interview tests. Data on the results of the essay test will be analyzed based on a rubric that differentiates student answers, then the scores based on the rubric are tabulated. Processing data from multiple-choice test results with open reasons, namely by analyzing the answers and reasons for students who experience confusion as a source of second-tier development on two-tier questions, after the early stages of the two-tier diagnostic test instrument were compiled, validation and reliability tests were then carried out.

Findings and Discussion

Development of a Two-tier Diagnostic Test Instrument for Detecting Misconceptions on Acid-Base Topics (TDTMMTA)

The concrete concept is clearly shown in the subject matter of acid-base indicators and the concept of pH in the environment. Abstract concepts are explained in the subject matter of acid-base theory. Concepts with abstract critical attributes are explained in the subject matter of acid-base theory and acid-base ionization constants. Concepts based on principles are explained in the subject matter of the concept of acid strength (pH) and pH calculations. Concepts that involve symbols are explained by the six main materials. The concept that describes a property is explained in the subject matter of acid-base theory: the concept of acid strength (pH), the acid-base ionization constant (Ka/Kb), and the concept of pH in the environment. While the concept that shows the size attribute is used in the subject matter of pH calculations, namely to calculate the pH of a solution, moles, molarity, volume of solution used, and how many grams of substance are contained in a solution.

Misconceptions obtained from this study focused on students only. The results of misconceptions obtained from the review of journals were used as the basis for making interview guidelines. Then the results of the interviews were used as material for making a descriptive test instrument. Furthermore, the results of the description test are used as material for making questions and distractors on multiple-choice test instruments with open reasons. The results of the implementation of the description test contributed to the development of multiple-choice tests with open reasons. In addition, based on the test results, the answers in the PP, MS, and TM categories were used as a reference for making distractors in multiple choice with open reasons. The results of administering multiple-choice tests with open reasons contributed to the development of the second tier in the first stage of the two-tier multiple-choice tests.

Based on the results of the previous stage, the results of the students' answers from the description test and multiple choice open-ended reasons were used as material for compiling the first tier and second tier of the developed two-tier multiple choice questions, which were then tested. Then the results of the first phase of the two-tier diagnostic test instrument trial resulted in 16 valid questions that covered the six subject matters used in accordance with the analysis of competency standards and basic competencies and the concept map described. The final stage of the diagnostic test is called the Two-Tier Diagnostic Test to Detect Misconceptions on Acid-Base Topics (TDTMMTA). TDTMMTA has a diagnostic function that aims to identify students' misconceptions on the topic of high school acids and bases. In addition, TDTMMTA was developed based on the stages developed by Treagust, where there is a defining content stage and the stage of obtaining information about students' misconceptions, which are important stages in analyzing possible sources of error. be the cause of the problem. Furthermore, TDTMMTA also uses supply response questions, which consist of questions, answer choices (first tier), and reason choices (second tier).

In the defining content stage, there are 4 stages that produce statements regarding the topic of acids and bases in accordance with the concepts and boundaries in accordance with the Competency Standards and Basic Competency. At the stage of obtaining information about students' misconceptions (obtaining information about students' misconceptions), sources of student errors were obtained based on the results of interviews with six informants, description tests for students, and multiple choice for students, so that in the final TDMTA results, items were obtained based on the results from the previous stages. The last criterion contained in this diagnostic test is to use supply and response questions, where the test consists of the first tier and the second tier. As for the diagnostic test criteria, a follow-up design was not developed for this instrument because the purpose of this instrument was only to identify student learning difficulties caused by misconceptions on the topic of acids and bases.

Quality of a Two-tier Diagnostic Test Instrument for Detecting Misconceptions on the Topic of Acids and Bases (TDTMMTA)

Based on the percentage, it can be seen that 40% of the distractors have bad criteria, and 18% of the distractors have very bad criteria. While the total distractors with very good and good criteria were only 26%. The first-tier distractor is shown in question numbers 2, 3, 5, 9, 13, and 14, which have distractor criteria that are dominated by very bad, bad, and not good criteria. In question numbers 2, 3, and 5, five students answered correctly, and only two students answered option a incorrectly. In this case, distractors b and e must be replaced because no one chose them, so they don't work, and distractor a must be replaced because the option is misleading, even though it was chosen by two students, because it is a distractor with very poor criteria. In problem number 3, distractor c must be omitted because it is a misleading distractor. In addition, distractors a and b are distractors that must be repaired, and distractor e must be removed because it doesn't work. In problem number 5, the distractors a and c must be omitted because they do not work, while b must be omitted

because it is a misleading distractor. While the distractor d must be fixed.

In number 9, distractor e must be omitted because it does not work, and distractor c must be omitted because it is misleading. while options a and d must be repaired. In number 13, distractor e must be removed because it doesn't work, distractor a must be removed because it is misleading, and distractors c and d must be repaired. In number 14, distractor d must be removed because it doesn't work, distractor a must be removed because it is misleading, and distractors b and e must be repaired. Whereas questions 1, 4, 6, 7, 8, 10, 11, 12, 15, and 16 have very good criteria, so they don't need to be corrected or eliminated. But for distractors that have poor, bad, or very bad criteria, the distractor must be repaired and replaced. So that it can be concluded, the first tier with distractors that are dominated by very bad and bad criteria is experienced in questions that can be answered correctly by more than 50% of students, as in questions numbers 2, 3, 5, 9, 13, and 14. In addition, in the first tier, most students can answer correctly easily, so there are many distractors that must be removed and corrected.

Based on this percentage, the total number of second-tier contractors with very bad and bad criteria fell to 30% and 13%, respectively. While the percentage of distractors with very good and good criteria increased to 17% and 13%, respectively. Based on the diagram, the percentage of bad and very bad distractor criteria is 43%. This figure has decreased when compared to the percentage of bad and very bad distractor criteria in the first two-tier diagnostic test. While the preparation of the second layer comes from the results of interviews, essay tests, multiple choice tests with open reasons, as well as the results of a literature review by researchers, on questions number 5, 8, 9, and 15, the second tier is dominated by very bad, very disturbing criteria, and not good.

In question number 5, distractors b and c did not work, so they had to be removed, while distractor a had to be removed because it was misleading by being chosen by 19 students. While the distraction needs to be fixed. In number 8, distractors a, c, and e must be omitted because they do not work, while distractor b must be omitted because it is misleading because it was chosen by six students. In question number 9, distractor a must be removed because it doesn't work, and distractor d must be removed because it is misleading because it was chosen by 12 students. Meanwhile, distractors b and e must be repaired. In question number 15, distractor b must be omitted because it doesn't work, and distractor 18 must be omitted because it is misleading by being chosen by 18 students. While the distractors b and d must be repaired. It can be concluded that in the second tier, the percentage of bad and very bad criteria on the distractor is smaller than in the first tier, so it can be said that in the second tier, the number of students deciding answers is more varied, and they do not tend to decide too easily on the right reason.

Based on these data, the percentage of correct answers in the first tier is greater than the percentage of correct answers in the second tier. For example, in question number 2, the percentage of students with correct answers in the first tier was 94%, while the percentage of students who answered correctly in both tiers was 40.54%, with the first tier answers being "correct statements regarding acid-base theory according to Bronsted-Lowry, a base is a substance that can accept a proton" and the correct statement on the second tier being "because a substance that acts as a base will form a conjugate acid because it accepts a proton donor". In addition, in question number 14, the percentage of students who answered correctly in the first tier was 75.67%, while the percentage of students who answered correctly in both tiers was 48.64%, with the answers in the first tier based on the question "the degree of acid ionization is 1×10^{-5}" and the correct statement on the second tier "because the concentration of the acid solution is 10 M."

Based on the research that has been done, a misconception with a percentage of 59.46% occurs in the concept of acid strength. While the misconception of the smallest percentage occurs in the concept of pH calculation. Other concepts, namely the concept of acid-base theory, the concept of pH in the environment, acid-base indicators, and acid-base ionization constants, have percentages of 40.87%, 37.83%, 21.62%, and 16.21%, respectively. The topic of acids and bases is a dense concept and consists of several concepts that must be well understood.

Conclusion

The development of a two-tier multiple choice diagnostic instrument resulted in a product in the form of a Two-tier Diagnostic Test to Detect Misconceptions on Acid-Base Topics (TDTMMTA). TDTMMTA consists of 16 items with sufficient validity criteria and high reliability criteria, with correlation coefficient values of 0.471 and 0.769, respectively. The use of TDTMMTA for class XI students resulted in a percentage of misconception categories in the acid-base theory concept of 40.87%, the acid-base indicator concept of 21.62%, the concept of pH of 59.46%, the concept of acid-base equilibrium constant (Ka/Kb) of 15.54%, the calculation of pH of 15.54%, and the application of the concept of pH in the environment of 37.83%. The TDTMMTA

instrument is used by the teacher as an alternative test to evaluate students' misconceptions on the topic of high school acids and bases at the end of learning as a preventive measure so that students do not experience advanced misconceptions. The results of the misconceptions obtained can be used as signs in the next learning process to avoid the occurrence of similar misconceptions. Meaningful learning by using appropriate teaching methods should be done well so that students do not just memorize and can avoid misconceptions. To obtain a variety of information on answers and misconceptions used in the instrument development stage, it is best to do this at various school levels.

Reference

A. Cetin, O. G. (2011). Development of a Three-tier Test to Assess High School Students' Understanding of Acids and Bases. *Procedia Social and Behavioral Sciences, 15*.

E. Nurfalah, e. a. (2020). Construction a Diagnostic Test in the Form of Two-tear Multiple Coice on Calculus Material. *Mathematics and Statistics, 8, 5*.

Hamalik, O. (2011). *Teaching and Learning Process.* Jakarta: Bumi Aksara.

Karadeniz, B. (2013). Using Two-tier to Identify Primary Students' Conceptual Understanding and Alternatif Conception Acid Base. *Mevlana International Journal of Education (MIJE), 3, 2*.

L. Yuniwarti, A. Y. (2020). Development of Attitude Assessment Instrument in Engineering Mathematics 1 Course to Access Discussion on MOOC Platform. *Journal of Physics: Conference Series, 1918*.

N. Afandi, S. P. (2022). Grateful Personality Development of Junior High School Students in East Kalimantan. *Southeast Asian Journal of Islamic Educaction, 4, 2*.

Ozmen, H. (2004). Some Student Misconceptions in Chemistry: A Literature Review of Chemical Bonding. *Journal of Science Education and Thecnology, 2, 13*.

P. Faturrohman, S. M. (2007). *Teaching and Learning Strategis Through Inculating General Concepts and Islamic Concepts.* Bandung: PT. Refika Aditama.

S.A. Pranajaya, A. F. (2020). Eksistensial Humanistik dalam Perspektif Bimbingan Konseling Islam Al-Ittizaan. *Jurnal Bimbingan Konseling Islam, 3, 1*.

Sheppard, K. (2006). High School Students Understanding of Titrations and Related Acid-Base Phenomena. *Chemistry Education Research and Practice, 7, 1*.

W.S. Zainuddin, M. M. (2022). Solusi Pembentukan Perilaku Nilai Moral Anak Usia Dini Melalui Pendidikan Islam. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini, 6, 5*.

Z. Muchtar, H. (2012). Analyzing of Student Misconceptions on Acid-Base Chemistry at Senior High School in Medan. *Journal of Education and Practice, 15, 3*.

Zulfiani, e. a. (2009). *Science Learning Strategy.* Jakarta: Lembaga Penelitian UIN Jakarta.