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Analysis of Critical Thinking and Problem Solving Abilities of High School Students Using Essay Tests on Chemical Solution Topic

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ABSTRACT

Critical thinking and problem solving skills are very important for an individual to have in the current era. Strong critical thinking and problem solving skills can play a role in facing competition and challenges at the global level. The importance of critical thinking and problem solving skills means that an analysis of these ability profiles is needed. One of the chemical materials that is closely related to problems in everyday life and requires high-level thinking skills is solution chemistry. The aim of this research is to analyze the critical thinking and problem solving abilities of high school students in solution chemistry material. This research was conducted at three high school schools in Kudus involving 80 students. The instruments used are 10 essay tests for each of critical thinking and problem solving skills as well as interviews. The results of the analysis of critical thinking and problem solving skills in the three schools are on average in the poor category. It is hoped that this research can provide an overview for schools regarding the profile of students' critical thinking and problem solving abilities which can later be used as evaluation material for schools.

Keywords: critical thinking ability, problem solving ability, chemical solution topic

INTRODUCTION

The 21st century is a century that encourages accelerated development of information and technology which causes human resources to be required to have many abilities [(1)]. One of the abilities needed in this century is the ability to think critically and solve problems [(2); (3)]. Critical thinking skills are students' way of thinking to analyze arguments and generate knowledge of each meaning and interpretation as well as to develop cohesive and logical reasoning patterns [(4)]. Problem solving is a student's ability to use his thinking process to solve problems through collecting facts, analyzing information, compiling various alternative solutions, and choosing the most effective problem solution [(5)]. Good critical thinking and problem solving skills can support individuals to face challenges and competition at the global level [(6); (7)].

Students have low critical thinking skills [(8); (9)]. One of the low critical thinking abilities is collecting the information needed to make the right decision [(10)]. Students' problem solving abilities are also in the low category [(11); (12); (13); (14)].

The ability to think critically and solve problems is very important in this century, so it is necessary to analyze student ability profiles for these two abilities. Profile analysis of critical thinking and problem solving abilities was carried out using test instruments [(15); (16); (17); (18)]. One form of test instrument is an essay/description test. This type of essay test requires students to organize, formulate and present their own answers, and reduces the possibility of students answering correctly by guessing [19]. The preparation of essay questions must be adjusted to the material, competencies and learning objectives to be achieved [20].

One of the chemistry topics that must be mastered at the SMA/MA level is solution chemistry. Basic Competency (KD) for solution chemistry used in this research is KD 3.12; and 3.14, namely buffer solution material, and solubility and solubility product (Ksp). This topic is related to calculating the pH of a solution and the solubility of a substance which requires understanding and algorithms, so critical thinking skills are very necessary. The results of the research show that students have not mastered the topic of buffer solution and Ksp as evidenced by the fact that there are more students who scored below the KKM than students who scored above the KKM [21]; [22]; [23]; [24]. The concept of this material is widely used to solve problems in everyday life, but teachers often do not emphasize this [25]; [26]; [27].

Solving problems in everyday life using solution chemistry concepts requires high level thinking skills such as critical thinking. Critical thinking is an ability that everyone must have in order to be able to solve problems both in the world of education and in everyday real life [28]. Analysis of the profile of critical thinking and problem solving abilities has been carried out by previous researchers.

Analysis of critical thinking and problem solving skills in schools is often only carried out in one school [9]; [29]; [30]; [12]; [31]. This does not represent the abilities measured in an area, it would be better if the research was conducted on more research subjects [32]; [33]. This research will be conducted on research subjects of three schools, each consisting of one class. The research results in the form of profile information on students' critical thinking and problem solving abilities, it is hoped that teachers and related parties at the school can determine effective learning strategies to improve these abilities.

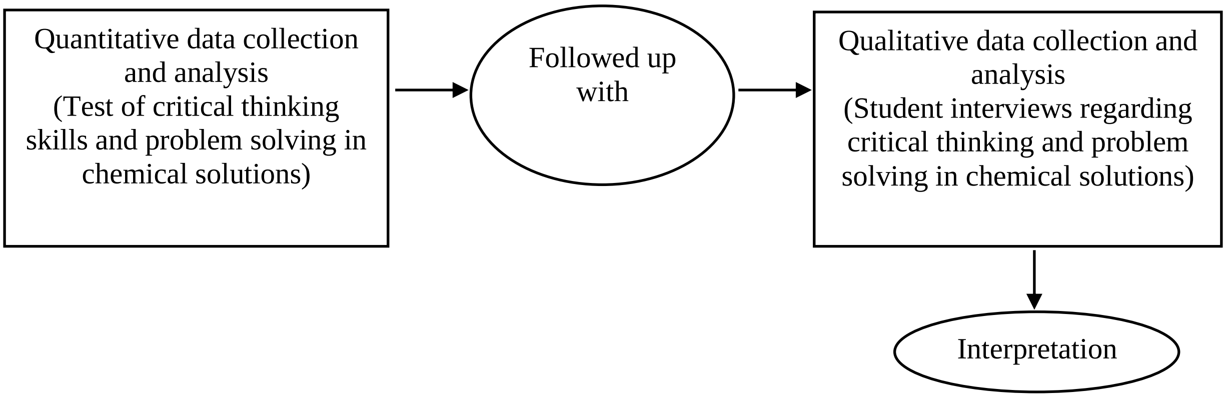
The results of observations from three Islamic schools in Kudus, Central Java, showed that the questions used were a combination of multiple choice and essay forms with a proportion of 80% multiple choice and 20% essay. This shows that most of the questions used are multiple choice. The weakness of multiple choice questions is that they generally cannot measure higher level thinking results and students can guess the correct answer [34]; [35]. The interview results show that the Ksp questions and buffer solution questions used in schools do not fully measure the critical thinking and problem solving skills that are so needed at this era.

The problems mentioned above, this research aims to analyze the critical thinking abilities and problem solving abilities of high school students using essay tests on the topic of solution chemistry. The benefit of this research is that teachers can obtain alternative evaluation tools on solution chemistry material that can measure students' critical thinking and problem solving abilities, and it is hoped that this can be an illustration in schools of students' critical thinking and problem solving abilities which can later be used as evaluation material for schools in develop and improve a better chemistry learning process.

METHODS

The research uses mixed methods. The use of mixed methods in research is because it has quantitative and qualitative data. Mixed methods research is a good design to use if the researcher wants to build on the strength of both quantitative and qualitative data [36].

The mixed research design used is the explanatory sequential design. This research design collects quantitative and qualitative data sequentially into two phases. The outline of the sequential explanatory design in the research occurs in Figure 1.



(37)

Figure 1. Explanatory Sequential Research Design

The research was conducted at 3 Islamic high schools in Kudus. Each of the 3 schools took 1 class with a total of 80 students. In the initial stage, observations and interviews were carried out at 3 schools in Kudus regarding the question instruments used and the chemistry learning process at school. The next stage is validation carried out by 4 experts on the question instruments, then small-scale trials on the critical thinking and problem solving questions that will be used. The aim of small- scale trials is to find out questions that are suitable for use. Test questions were given to 25 grade 12 students. The results of the small-scale trials contained 10 items to measure critical thinking skills and 10 problem solving questions that could be used. The next stage is giving critical thinking and problem solving test questions to students in the 3 schools. The final stage is data processing in the form of test results and interviews, critical thinking and problem solving.

The data collection instruments used were interview sheets and critical thinking tests & problem solving tests. The critical thinking ability indicators measured are interpretation, analysis, conclusion, evaluation and expansion [38]. There are four stages of problem solving ability measured, namely understanding the problem, preparing a plan, implementing the plan, and checking again [39]. Data obtained from school observations and teacher interviews are presented into a description. The results of the critical thinking and problem solving ability tests were transformed into a scale and then descriptive analysis was carried out. Criteria for critical thinking and problem solving abilities are presented in Table 1.

Table 1. Criteria for Critical Thinking and Problem Solving Ability Based on Test Results

Mark	Value Interval	Criteria
A	$80 < M \leq 100$	Very good
B	$60 < M \leq 80$	Good
C	$40 < M \leq 60$	Enough
D	$20 < M \leq 40$	Less
E	$0 < M \leq 20$	Very less

RESULT & DISCUSSION

a. Critical Thinking Ability

The critical thinking questions that have been created measure five indicators of critical thinking, namely interpretation, analysis, conclusion, evaluation, and expansion. Interpretation is the skill of understanding and expressing the meaning contained in facts, information and data obtained from observation. Analysis is a skill for identifying the true meaning and inferential relationships between data, statements, questions, concepts, or other forms obtained in learning activities. Conclusion is the skill of making predictions based on identification results and to conclude logically and precisely.

Evaluation is the skill of assessing the quality of statements and other explanatory representations. Expansion is the skill of presenting reasoning and justifying convincing arguments based on data or concepts [38]. The overall percentage results for each critical thinking indicator are presented in Figure 2.

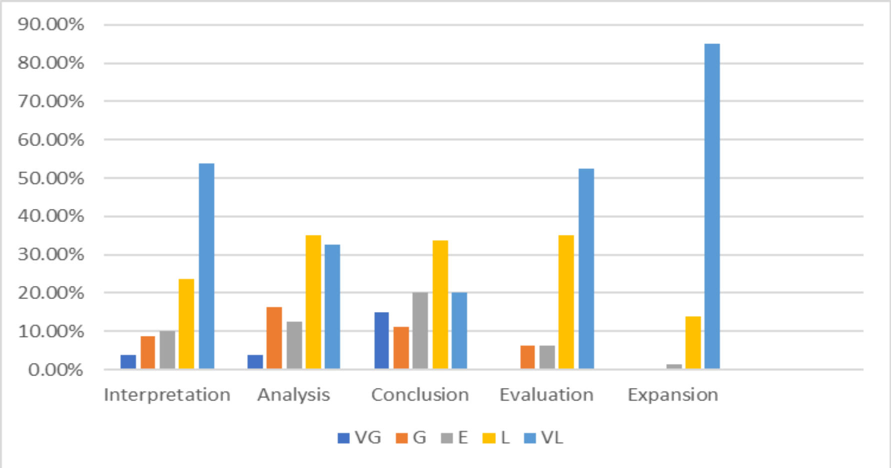


Figure 2. Critical Thinking Profile Per Indicator

Figure 2 shows that the most interpretation indicators are in the very poor category, the most analysis indicators are in the very poor category, the conclusion indicators, evaluation indicators and expansion indicators are respectively the most common in the very poor category. These results show that the average critical thinking ability of students is in the very poor category. Poor critical thinking skills are caused by several factors. The interview results showed that the practice questions and chemistry exams on Ksp material and buffer solutions given to students had not fully trained their critical thinking skills. The Ksp material and buffer solutions given to students do not yet relate it to everyday life problems. Students who memorize more often, lack of exercises and activities that encourage critical thinking skills are one of the factors in students' lack of critical thinking skills [29]; [40].

Interpretation indicator ability is measured with 2 questions. One example that measures interpretation indicators is presented in Figure 3.

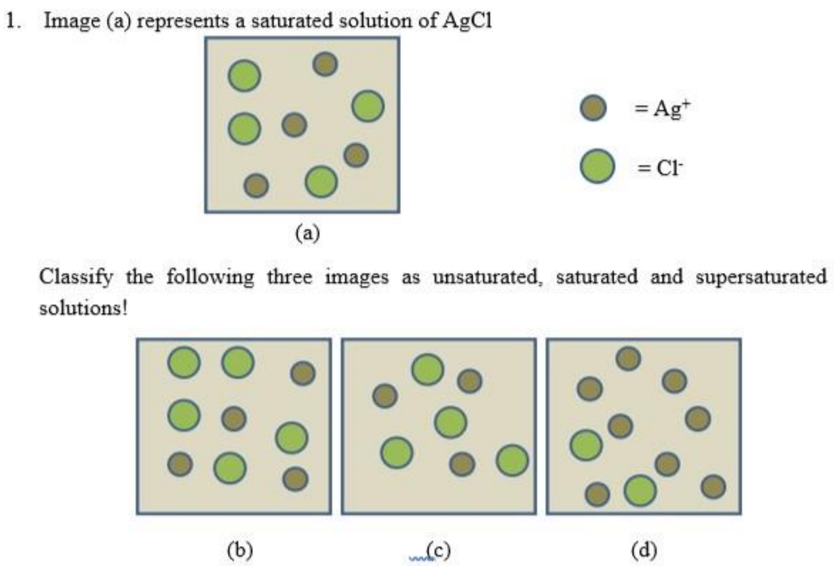


Figure 3. Questions measuring interpretation indicators

Most students cannot interpret images and connect them with the right reasons. Students in question number 1 in classifying saturated, unsaturated and supersaturated solutions compare $[Ag^+]$ to $[Cl^-]$. Students think that if $[Ag^+]$ is smaller than $[Cl^-]$ then it is considered unsaturated, if $[Ag^+]$ is the same as $[Cl^-]$ then it is exactly saturated, and if $[Ag^+]$ is greater than $[Cl^-]$ then it is considered supersaturated. The results of students' answers to question 1 are presented in Figure 4.

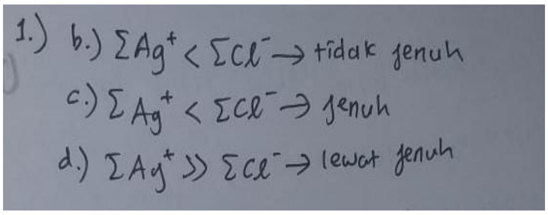


Figure 4. Student answers to question 1

The results of interviews with students are shown as follows:

P	:	*Do you understand question number 1?*
S	:	*Understand ma'am but doubtful*
P	:	*What is the meaning of this question and how to classify what is saturated, unsaturated and supersaturated?*
S	:	*Image (b) $[Ag^+]$ is the same as $[Cl^-]$ so it is saturated, Image (c) $[Ag^+]$ is smaller than $[Cl^-]$ so it is saturated so it is not saturated. Image (d) $[Ag^+]$ is greater than $[Cl^-]$ so it is supersaturated.*

The test and interview results show that the concept presented by the students is not accurate, because the classification of saturated, supersaturated and unsaturated solutions can be seen from the comparison of the Qsp and Ksp values. In the unsettled state if the price is $[A^{y+}]^x \cdot [B^{x-}]^y < Ksp$, if the value is $[A^{y+}]^x \cdot [B^{x-}]^y = Ksp$ then reaches a saturated solution, if the value is $[A^{y+}]^x \cdot [B^{x-}]^y > Ksp$ means it is past saturation or sediment has occurred. Qsp is generally the product of the ion concentration raised to the power of the coefficient. The criteria for determining whether the ions in the solution will combine to form a precipitate must be compared with their Ksp [41].

Students cannot classify images that represent saturated, unsaturated and supersaturated solutions. This shows that students' image interpretation skills are low. This is in line with research from [42]; [43] which results in low students' image and graphic representation abilities. Students who have low understanding have low representation abilities because students are less able to understand images correctly in solving a problem [44]. Students whose visual representation abilities are low are because they have an unstructured way of thinking and do not master concepts [45].

The ability of analytical indicators is measured with 2 questions. One example of measuring analytical indicators is presented in Figure 5.

Formic acid (HCOOH) is an acid that can be found in many insects as a means of defense. Formic acid can be used as a buffer system with sodium formate. If a buffer mixture is formed from 500 mL of 1 M HCOOH solution (Ka HCOOH = 2×10^{-4}) and 500 mL of 1 M HCOONa solution, plus 100 mL of HBr solution whose pH is 1. Give an analysis of the change in pH value before and after adding HBr solution!

Figure 5. Questions measuring analytical indicators

Most students cannot identify meaning and make connections between data. The student in question number 6 did not analyze the change in pH of the buffer solution after adding a small amount of strong acid, because he did not know how to find moles of HBr with known concentration and volume. This shows that students with poor analytical skills cannot connect data to find the moles of a compound. The results of students' answers to question 6 are presented in Figure 6.

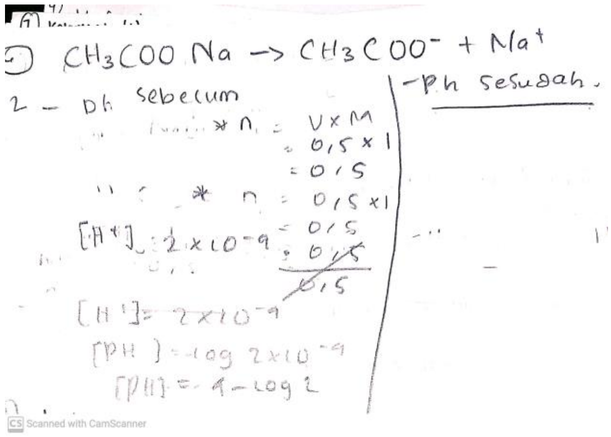


Figure 6. Student answers to question 6

The results of interviews with students are shown as follows:

P	:	*What is the meaning of this question and how to determine the effect of adding a small amount of strong acid on the pH of the buffer solution?*
S	:	*Question number 6 determines the pH of the buffer before and after adding HBr. I usually work on the pH of the buffer solution before adding HBr, because I'm used to working on problems like that. But for the pH after adding HBr it cannot be done because there are no moles.*

Students cannot analyze the pH of the buffer solution after adding a little acid because they cannot relate the data. This shows that students' analytical skills need to be improved. This is in line with research from Maisaroh *et al.*, (2020) which resulted in very low data linking abilities because there were two concepts combined into one problem so that students had difficulty understanding the concepts of the material clearly. Students have not been able to analyze the relationship between information and concepts and existing questions and have not been able to identify relationships between questions and concepts [(47)]. Factors that influence students' ability to relate data are low conceptual understanding, lack of language mastery of question requests, lack of accuracy and forgetting the formula to be used, low reasoning ability [(48)].

The ability of the conclusion indicator is measured with 2 questions. One example of measuring the conclusion indicators is presented in Figure 7.

XI science 2 is looking at the following solutions

(1) 100 mL $Ca(OH)_2$ 0,1 M
(2) 100 mL NH_3 0,2 M
(3) 200 mL HCl 0,05 M
(4) 200 mL HF 0,1 M
(5) 200 mL HNO_3 0,1 M

One class is divided into 4 groups.

- Group 1 tested a mixture of solutions (1) and (2),
- Group 2 tested a mixture of solutions (2) and (3),
- Group 3 tested a mixture of solutions (3) and (4),
- Group 4 tested a mixture of solutions (4) and (5).

After analysis, one of the groups contained a mixture that could form a buffer solution (its pH remained relatively unchanged when a little acid and base were added). Based on this description, which group does the mixture form a buffer?

Figure 7. Questions measuring conclusion indicators

Most students cannot make estimates and conclusions correctly and logically. Students in question number 7 cannot determine the mixture that can form a buffer solution, because students have difficulty determining which substances are acidic and basic. Students have difficulty distinguishing between buffer solutions and non-buffer solutions because students cannot differentiate between acidic and basic compounds (24). These difficulties indicate that students are weak in understanding the concept of buffer solutions and the prerequisite material for buffer solutions (49). The results of students' answers to question 7 are presented in Figure 8.

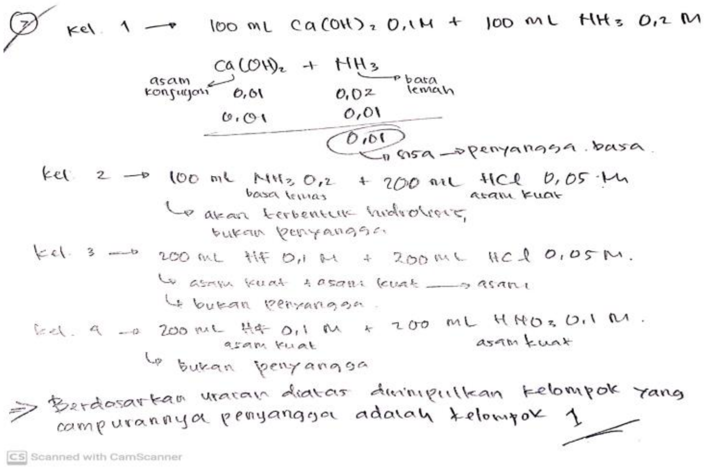


Figure 8. Student answers to question 7

The results of interviews with students are shown as follows:

P	:	*How do you deduce the group whose mixture forms a buffer solution?*
S	:	*I concluded that the group whose mixture formed a buffer solution was group 1 which tested the $Ca(OH)_2$ and NH_3 solution, because $Ca(OH)_2$ functions as a conjugate acid and NH_3 functions as a weak base.* *Group 2 is not a buffer because hydrolysis will occur* *Group 3 is not a buffer because they are both acids* *Group 4 is not a buffer because they are both acids*

The test and interview results showed that students were unable to estimate the mixture of solutions that could form a buffer solution. This shows that students' inference abilities are low. This is in line with research from Agus & Purnama, (2022) that students' critical thinking abilities for concluding indicators are very low. Making conclusions can be seen from students' ability to make statements that have been proven [(51)].

The ability of evaluation indicators is measured with 2 questions. One example of measuring evaluation indicators is presented in Figure 9.

The step in the commercial process (making a profit) in the process of obtaining magnesium is sourced from sea water involving the deposition of Mg^{2+} as $Mg(OH)_2$. Does $Mg(OH)_2$ precipitate occur when mixed:

a. 300 mL solution $MgCl_2$ 0,06 M with 200 mL solution NH_4OH 0,1 M

b. 200 mL solution $MgCl_2$ 0,06 M with 400 mL solution NH_4OH 0,1 M dan 400 mL solution NH_4Cl 0,02 M? Is Known K_b $NH_4OH(aq) = 1{,}8 \times 10^{-5}$, K_{sp} $Mg(OH)_2 = 1{,}2 \times 10^{-11}$

Figure 9. Questions measuring evaluation indicators

Most students cannot assess the statements and data presented. Students in question number 4 cannot determine whether the mixture provided can form a precipitate or not. Students in question number 4 cannot determine the Qsp of the solution mixture so students cannot judge whether the mixture forms a precipitate or not. In question number 4, students also still have not mastered the criteria for a settled solution when viewed from the Qsp value. This is in accordance with research from Ihsan *et al.*, (2021) which shows that students still have difficulty assessing the occurrence of deposits because students do not understand the Qsp calculations and the formulas used. The results of students' answers to question 4 are presented in Figure 10.

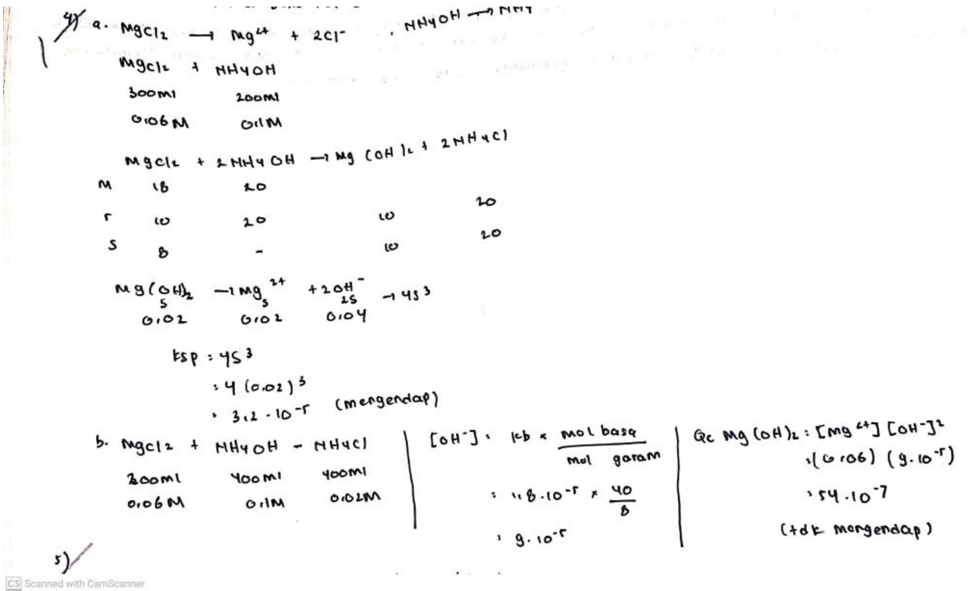


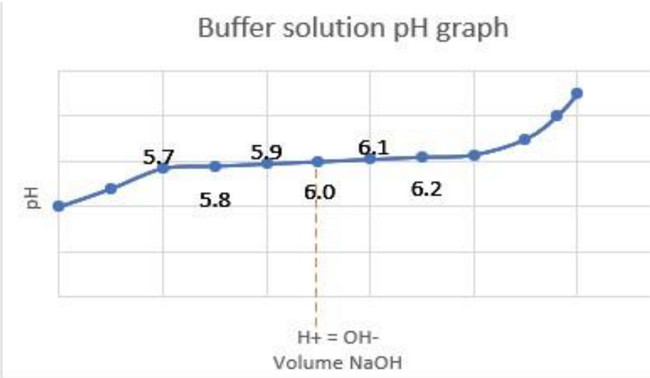
Figure 10. Student answers to question 4

The results of interviews with students are shown as follows:

P	:	*How do you judge whether the solution mixture in question number 4 has settled or not?*
S	:	*In number 4a I calculated the Ksp of $4s^3$ of $2OH^-$. Obtaining the Ksp value then 4a settles.* *In number 4b I first calculated [OH-] using the base buffer formula, then calculated Qc = $[Mg^{2+}][OH^-]$. The value of $[Mg^{2+}]$=0.06 M multiplied by $[OH^-]$ produces Qsp so 4b does not precipitate.*

Test and interview results show students are unable to make judgments from the data presented. This shows that students' evaluation skills are low. Research from [47]; [53] also shows indicators of critical thinking, namely student evaluations in the low category. The student has tried to solve the problem in his own way but it is not correct because the student is wrong in calculating the Qsp value on the question which results in giving the wrong assessment. Another case that occurs is that students can calculate the Qsp value but determine incorrectly whether it settles or not. Students are only able to complete calculations (inference) but are unable to interpret the answers (evaluation) [17].

The ability of expansion indicators is measured with 2 questions. One example of measuring expansion indicators is presented in Figure 11.



The graph above is a graph of a buffer solution made by mixing 10 mL of 0.2 M HCN solution with 10 mL of 0.2 M NaCN solution. After that, the strong base NaOH was added to the buffer. Based on these data, give your argument for the mass of NaOH that must be added so that the pH of the buffer solution is 6.3. Explain!

Figure 11. Questions measuring expansion ability

Most students cannot present reasoning and convincing arguments based on data or concepts. Students in question number 10 did not master the concept of adding a small amount of acid and base to a buffer solution. Students in question number 10 were unable to connect the graph with the data provided. The results of student answers are presented in Figure 12.

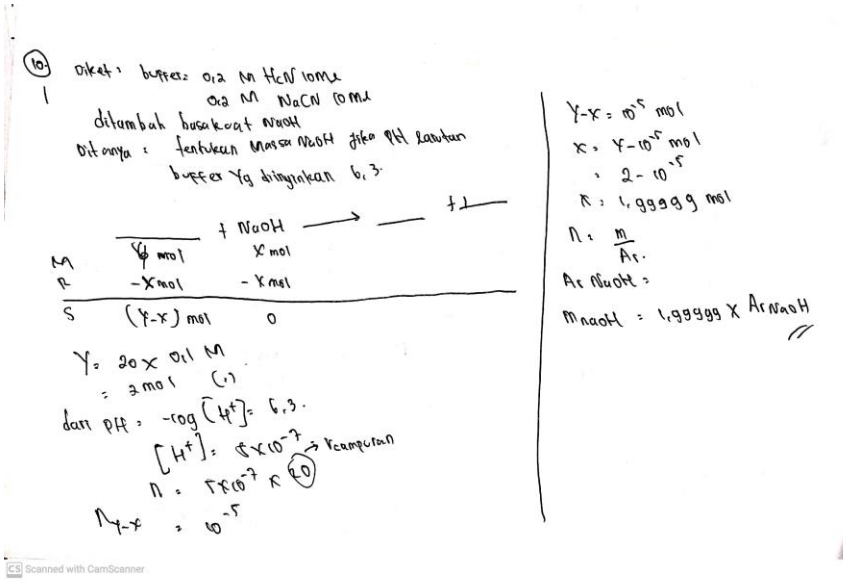


Figure 12. Student answers to question 10

The results of interviews with students are shown as follows

P	:	*How do you calculate the mass of NaOH that must be added to form a buffer solution with a pH of 6.3?*
S	:	*First I determined the final mole using Mrs. Let my mole of HCN be y and let my mole of NaOH be x so the student's mole of HCN is y-x and the mole of NaCN is x. To find the mole value of y, multiplying 20x0.1M gets 2 mol. Then the value of x = 1.99 mol. The mass of NaOH is mol/Ar, so 1.99xArNaOH. But I'm still unsure about my answer.*
P	:	*Why don't you include the ka value in the buffer formula?*
S	:	*Because it's not known about the matter, ma'am*

Test and interview results show that students' expansion abilities are very low. This is in accordance with research from [54] which shows students presenting reasoning or arguments in the low category. On the indicator of constructing good arguments, many students do not complete the answers to the questions [55]. Problems are not resolved properly because students are not able to apply the correct way of thinking, so students do not succeed in mastering the material soal [55].

b. Problem Solving ability

Problem solving questions have been created with problem solving stages, namely understanding the problem, developing a plan, implementing the plan, and checking again. N. H. Astuti *et al.,* (2020) explains the stages of understanding students' problems by identifying what is known, what exists, quantities, relationships, related values, and what they are looking for. In the planning stage, students identify the operations involved as well as the strategies needed to solve a given problem. In the stage of implementing the plan, students maintain the plan that has been chosen. In the re-checking stage, students re-check the steps previously involved in solving the problem. The overall percentage results for each problem solving stage are presented in Figure 13.

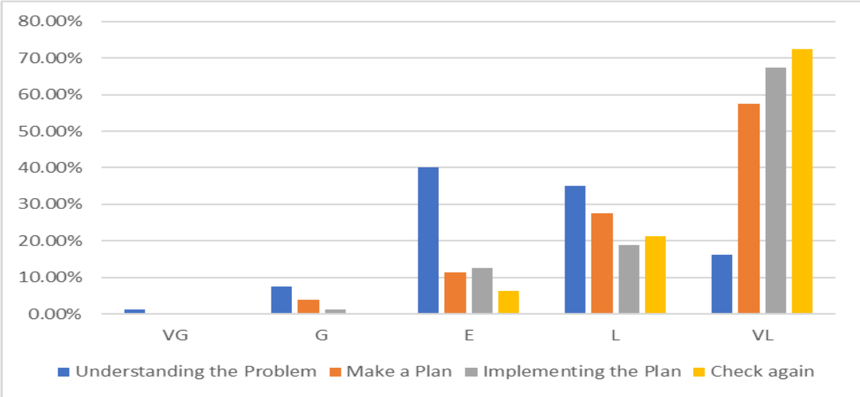


Figure 13. Problem Solving Profile for each Stage

Figure 13 shows the stage of understanding the problem most in the sufficient category. The stage of preparing a plan, the stage of implementing a plan, and the stage of re-checking are each in the very poor category. These results show that the average problem solving ability of students is in the very poor category. The results of this research are supported by research from Peranginangin & Surya, (2017), namely that the majority of students are unable to complete all stages of problem solving indicators needed to solve the questions given. Poor problem solving abilities are caused by several factors. Students' problem solving abilities are lacking because students are not careful enough, do not understand the concept of the questions, and are not used to non-ritual questions [(57)]. Students cannot solve chemistry problems because teachers do not provide effective problem solving training, lack of understanding of chemical principles and rules, lack of understanding of the problem, and poor teacher motivation [(58)].
There are 10 questions to measure problem solving abilities, each of which includes problem solving stages. One example of a question that measures understanding of the problem is presented in Figure 14.

The paint contains a mixture of chemicals so that the paint can last a long time from various disturbances, such as fading easily due to rainwater. Paint that is durable and does not fade easily shows that its solubility in water is very poor. A paint manufacturer mixes $PbCl_2$ so that the paint it produces lasts longer when applied to walls. After testing in the laboratory, the results obtained were that the water resistance of the paint was not good, so the paint manufacturer replaced $PbCl_2$ with $CaCO_3$. Lab test results show that $CaCO_3$is better at water resistance than $PbCl_2$ (K_{sp} $CaCO_3 = 2{,}8 \times 10^{-9}$; K_{sp} $PbCl_2 = 1{,}6 \times 10^{-5}$).

a. Write the ksp equations K_{sp} dari $CaCO_3$ dan $PbCl_2$
b. Calculate the solubility of $CaCO_3$ dan $PbCl_2$!
c. Does the paint mixture chosen by the paint manufacturer match your calculations?
d. What can you conclude from the results obtained?

Figure 14. Problem solving questions

The stage of understanding the problem is in question (a). Most of the students are in the sufficient category. Students can understand the problem but cannot write the Ksp equation for one of the compounds. This is because students are not precise in writing the ionization reactions of compounds. This is because students still have difficulty with the Ksp requirement material, namely ionization reactions. This is in line with [(59); (60); (61)] which results in students having difficulty writing ionization equations.

Many students make mistakes in determining positive and negative ions and determining the charge of the decomposed ions, which has an impact on writing Ksp expressions [(22)]. The results of student answers are presented in Figure 15.

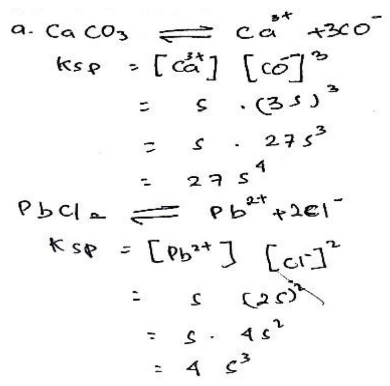


Figure 15. Student answers at the understanding the problem stage

The results of interviews with students are shown as follows:

P	:	*Do you understand question number 1 (a)?*
S	:	*Got it ma'am*
P	:	*What is the equation for the Ksp of $CaCO_3$ and $PbCl_2$?*
S	:	*$CaCO_3$ decomposes into Ca^{3+} + $3CO^-$ so the Ksp equation is $27s^4$. PbCl2 $PbCl_2$ decomposes into Pb^{2+} + $2Cl^-$ so the Ksp expression is $4s^3$*

The test and interview results show that students can understand the problem but are less precise in determining the Ksp equation. This is in line with research from [(62)] which resulted in students showing good performance at the stage of understanding the problem [(63); (64); (65)].

The stage of preparing a plan is in question (b). Most of the students are in the very poor category. The stage of preparing a plan is low because at the stage of understanding the problem it is not accurate to determine the value of the equation, so it will have an effect on determining the solubility value of the two compounds presented. The most dominant difficulty for students in the solubility product and solubility product material is the application of Ksp, including determining Ksp, the relationship between Ksp and s, and determining the solubility product constant equation [(66)]. Other research from Ihsan *et al.*, (2021) shows that students have the greatest difficulty in Ksp material, namely calculating solubility based on the Ksp value of 69%. The results of student answers are presented in Figure 16.

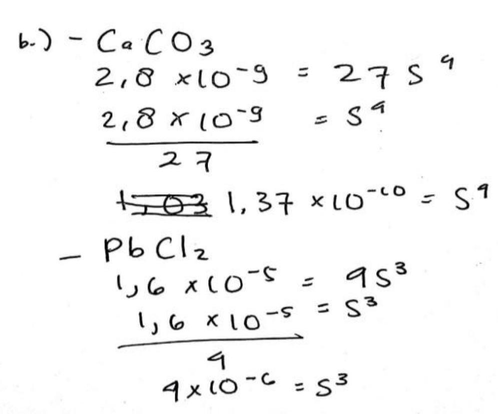


Figure 16. Students' answers at the planning stage

The results of interviews with students are shown as follows:

P	:	*How do you calculate the solubility of $CaCO_3$ and $PbCl_2$?*
S	:	*$CaCO_3$ decomposes into Ca^{3+} + $3CO^-$ so the Ksp equation is $27s^4$, then the s is $1,37x10^{-10}$ $PbCl_2$ decomposes into Pb^{2+} + $2Cl^-$ so the Ksp equation is 4s3 then the s is $4x10^{-6}$*

The test and interview results showed that most students' problem solving abilities at the planning stage were low as evidenced by students not being able to determine the solubility value correctly because they made a mistake at the stage of determining the Ksp equation. This is in line with research from A. Rahmawati & Warmi, (2022); Indahsari & Fitrianna, (2019); Pramono, (2017) which results in low students' planning abilities. Students cannot make plans because students are not used to it and immediately work on problems without making a plan first, and have difficulty entering data into formulas that have been written, and students are not careful in the calculations they make [(12)].

The stage of implementing the plan is in question (c). Most students at this stage are in the very poor category because they are influenced by previous stages. In the previous stage, students were unable to express the Ksp equation and calculate the solubility value, so students were unable to determine which compounds were more soluble in water. Students already understand the relationship between the s value and solubility, but students make mistakes when doing calculations. The results of student answers are presented in Figure 17.

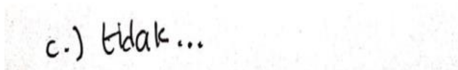


Figure 17. Student answers at the stage of implementing the plan

The results of interviews with students are shown as follows:

P	:	*How do you determine which compounds are more soluble in water?*
S	:	*Judging from the s value I'm looking for ma'am. The S for $CaCO_3$ is $1,37x10^{-10}$ and the s of $PbCl_2$ adalah $4x10^{-6}$, so the more insoluble is $PbCl_2$. So the choice of paint does not match the calculations*

The test and interview results showed that the ability of most students at the stage of implementing the plan was low, which was proven by the students to be wrong in determining which compounds were more soluble and which were not more soluble in water. This is in line with research from [(70); (71)] which results in low students' ability to carry out plans. This is because students at the previous stage were unable to answer the questions correctly. Students make mistakes in carrying out plans because students are not careful when making plans, so that when they finish at the end a solution is not found (Indahsari & Fitrianna, 2019).

The re-checking stage is in question (d). At this stage the average ability of students is in the very poor category. The re-checking stage is the stage of re-checking the steps previously involved in solving the problem by concluding or evaluating the answers in the previous step. The results of the previous stage were that students were not correct in answering, so students were wrong in drawing conclusions. The results of students' answers are in Figure 18.

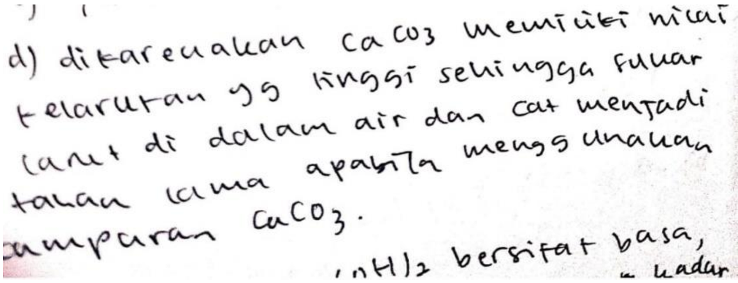


Figure 18. Student answers at the re-checking stage

The results of interviews with students are shown as follows:

P	:	*How do you conclude question number 1?*
S	:	*The s value of $CaCO_3$ is greater than $PbCl_2$ so the solubility of $CaCO_3$ has worse solubility compared to $PbCl_2$*
P	:	*The S of $CaCO_3$ is $1,37x10^{-10}$ and the s of $PbCl_2$ is $4x10^{-6}$ but why is the s of $CaCO_3$ greater than $PbCl_2$?*
S	:	*Oh yes ma'am, I forgot that if the rank is (-) then it's the opposite*

The test and interview results showed that the ability of most students at the re-examination stage was low, which was proven by students to be wrong in concluding which compounds were more soluble and which were not more soluble in water. This is in line with research from Damianti & Afriansyah, (2022); Fitria *et al*., (2018) which results in low student re-examination stage abilities. The rechecking stage aims to recheck the answer process and check for errors. Pramono, (2017) explains that this stage checks the suitability of the formulas and theorems that will be used to solve the problem, but students do not do this so that at this stage students' abilities are low. This is in line with research from [74] which explains that students tend to ignore the importance of verifying whether the answer is correct and makes sense.

CONCLUSION

The critical thinking ability profile of students at three schools in Kudus, Central Java, Indonesia is in the poor category. School X has an average score of 24.55, school Y's average score is 23.65, and school Z's average score is 27.02. 3. Profile of problem solving abilities of students at three schools in Kudus, Central Java, Indonesia in the poor category. School X has an average score of 23.75, school Y's average score is 26.34, and school Z's average score is 29.13. The research results obtained indicate the need for efforts by chemistry teachers and schools to improve students' critical thinking and problem solving abilities.

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